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LIVING MATTER:

ITS CYCLE OF GROWTH AND DECLINE IN ANIMAL ORGANISMS.

C. A. STEPHENS.

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B.U.S.M. '87

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PREFATORY NOTE.

THE present small volume is a *résumé* of an extended investigation into the causes of "old age" and organic death. It is furthermore designed as an introduction to a number of handbooks treating of the re-vitalization of the human organism.

The initial steps of the investigation touching the material basis of life are noted, and also such deductions and conclusions as have seemed legitimately to result from what has been done.

To counteract "old age," and death as a resultant from aging, the first step has been to inquire what are the actual physical and physiological causes of these conditions, in order that the proper remedial agencies may be determined. To this inquiry, and the answer obtained to it, the following pages are devoted.

Other and later steps of the investigation look to the removal of the causes of old-aging and death, and involve special lines of research in, —

I. The Intimate Life of the "cells" of living matter in young and old tissues, as observed under very high microscropic power.

II. Self-Renewal; the renovation of the biogen, or living matter, of aging tissues, *in situ*.

III. New creations of vital capacity in the human organism.

IV. Vital Armor and Vital Re-enforcement.

V. Inflammation as an agent of vital restoration.

VI. The Instinctive Human Hope of Immortality; its physical basis and what it portends.

VII. Sexual Economy; the utilization of the reproductive function for the regeneration of the parent organism.

VIII. Living to Live; the conservation of surplus vital energy, with methods for its reversion to the organism.

The investigation is directed to a practical demonstration of these theorems in vital physics.

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LIVING MATTER:

ITS CYCLE OF GROWTH AND DECLINE IN ANIMAL ORGANISMS.

I.

OF MATTER UNIVERSALLY.

Of the origin, intimate constitution, and destiny of universal matter we know nothing, as yet.

Condensed in suns, planets, and their satellites, we behold matter rotating in a rarefied ocean of itself, passing through great cycles of change in equally grand epochs of time. The greater globes glow fiercely, yielding light, heat, and electricity in enormous measures. The smaller globes display the same phenomena in minor degree, and, at certain periods of their growth, when influenced by the light, heat, and electricity of neighboring larger globes, bloom over their external surfaces with life. In other words, under certain quantitative conditions of aggregation, matter may become nebulously diffused in space; under other conditions, it may blaze and scintillate with solar splendor; and again, where the mass is such that heat is generated only up to certain low limits, and other globes shine kindly on it, it may live. As a mode of living, the surface of these moderately warm and externally lighted globes may swarm with forms and types of living things.

Looked at in the larger light, we are led to regard life as one of a series of phenomena, or "energies," which matter is capable of giving rise to. It now seems

most probable, too, that this *sentient* or vital property of matter is an absolute attribute, perhaps its primary and ultimate attribute, the sentient, *divine* cause of nature and motion universally; that the universe is essentially and fundamentally a *living* universe.

Some of the most eminent scientific minds of the current half-century incline to the hypothesis that matter is a "double-faced unity," like the shield of knightly story, physical on one side, vital on the other; that the "atoms" possess physical and vital attributes; and that from this bipartite source of phenomena all nature emerges. The hypothesis may serve its purpose as a working basis, which is all, probably, that its propounders expect of it. It is open, however, to much criticism on the part of those who fear the tendencies of scientific thought. An "atom," thus portrayed as a double-faced unit, is as logically inconceivable as is a universe of atoms governed both by natural law and a separate personal director. Chaos of thought is the ultimate result of either proposition. Material, inert "atoms" are argued to exist from the *inertia* of matter. But what know we of inertia? Nothing. Every indication, indeed, points to the conclusion that "inertia" is but an apparent and not the real condition of matter. The conception of an *atom*, too, is equally superficial and presently derived. The entire drift of research points to a practically infinite attenuation of matter, carried far out past the ethereal condition, toward that condition which we imperfectly postulate as "spirit."

With the question whether matter is really *material* or not we do not here attempt to deal. Matter is the mystery of mysteries. We conceive of it as sentient, and that its sentience is a constant, constantly expended in motion and every form of dynamic energy,

and as constantly renewed in the cycle of the universe. Sentience is the origin and end of all natural phenomena. Matter moves and returns to itself through the great cycle of universal phenomena. Like eternity, infinity, and immortality, its symbol is a circle. Matter *feels;* hence the universe has everywhere a low degree of sensory perception — *sense* to proceed toward an object; and this sense to proceed toward an object is that which gives semblance of design in nature.

But how has matter sentient, fundamentally, come to lie in the apparently lifeless masses which we contemplate in the terrestrial sphere and the other orbs of space? The answer is, from the gigantic action of this same inherent property, on a vast scale, either within the earth itself or while associated with other matter in vaster bulk. It was then moulded and cast by virtue of its own titanic action and recoil. Yet do these thoughts but bring us to the verge of the great question, What is matter? — a question which no terrestrial mind can answer. It is the unknown. Whence came it, and whither does it proceed in its amazing pageant and progress through space? From so august an inquiry we withdraw, and confine our thoughts to humbler questions.

The stout old astronomer, Kepler, who, with what seems to most men a puerile credulity, believed the earth to be a living creature, had at least a glimmering of the truth in his odd theory. The earth lives in a certain sense; not the self-conscious life of an animate organism, yet sentient in low degree.

Gravitation and natural phenomena result from this primary sentient impulse: a static impulse which constitutes matter what we behold it to be; an impulse constantly expended in motion and renewed *a tergo* from the ultimate results of motion.

What seems the inertia of matter is a condition of equilibration; what appears to be dead matter is only matter at a dead-lock, from which it may be released to live. This *living*, that is to say, primarily sentient, property is eternal to and inseparable from the ultimate atom, a *constant* amid the changing phenomena of sun and world systems; and even when locked in the apparently dead clod, or stick, or stone, the initial atoms are still living atoms, robbed of not one whit of their static ability to feel and to live. Such is the present conception.

Philosophy taught much concerning certain supposititious properties of matter, and has portrayed its impenetrability, porosity, extensibility, ductility, inertia, *et als*. These were held to be its prime properties. As a necessity of theological tenets, matter was depicted as the lifeless material of a manufactured universe.

But the philosophy of to-day postulates matter, not as lifeless but as living, not the inert substance of a created world, but the living substance of a self-creating and self-sustaining universe; that matter is itself *creative* of natural phenomena by virtue of that static attribute which resides at the core of every "atom."

The words *energy*, *vital energy*, *life*, *sentience*, *sensation*, *feeling*, *vital power*, *vitality*, and *force* are often so loosely and variously used in popular and even in scientific works, that it is difficult to define, by the use of any one of them, this static attribute of matter from which vital phenomena and all natural phenomena come forth.

On the other hand, to invent new terms from Greek or Latin word roots is an ungracious task, which in the end but adds to the general confusion. Better restrict

than widen it, we believe; and that there be as little loss of perspicuity as possible, let the word *sentience*, as here presently used, be allowed to signify the capacity to feel merely, a sentience of low degree in quantity far, very far, beneath that evinced by even the lowest forms of life. The life of even an amœba is that displayed in a peculiar aggregation of sentient matter; and hence vital characteristics far above that of matter, not thus collocated, are evinced.

Atomicity, indeed, is a depth of matter of which we know nothing; the *life* of unorganized matter is expressed mainly in the effects which we term gravitation and the natural forces. Of atoms such as probably radiate from the sun, no apparatus yet devised by man enables us to obtain definition in terms of weight or size.

We know that we stand upon something solid and resistant to touch. This is the testimony of sense. Whether the atoms be "physical points," centres of radiation of energy, is as debatable to-day as in Berkeley's time. Nor is it likely that a solution of this problem can be immediately reached, since all our knowledge points to a well-nigh infinite subdivison and rarefaction of matter. But, as an incident of the broadening of knowledge in this particular, there may be remarked the return of scientific opinion from the extremes of the dynamic hypothesis toward the Newtonian doctrine of matter. To treat of *force* as something distinct from matter is a solecism.

Briefly, the universe exhibits to the senses of living creatures the phenomena of matter and motion; and ever since man first attempted to reason on the subject, there has been presented to his more or less developed mind the problem of the origin of the one and the

cause of the other. Hence there have been many theories and hypotheses of creation and creator. Life especially has ever been a grand stimulative theme to such speculation; which is not wonderful, since out of matter in motion life and intelligence are seen to arise. To supply an origin of matter and a cause of life, man has portrayed anthropomorphic creators of all imaginary degrees of power, benignity, and malignity. To explain life's ills, gods and devils have been made to walk the earth, and to form the warp and woof of a thousand superstitions. The development of mind gradually reduced polytheism to monotheism; and in the existent religions of this century we find creation generally ascribed to a single deity.

Science and philosophy, equally with ecclesiasticism, have been drawn to theorize as to the origin of the world and the cause of phenomena, particularly vital phenomena. A school of materialism dates back to the days of Democritus and Lucretius; nor have the moderns much improved on the doctrines of these fathers of the creed, although we have more elaborately formulated hypotheses as to the origin and cause of things terrestrial and universal. Human heads are not much clearer on that subject now than they were twenty-five centuries ago; though unquestionably men were never in possession of so many facts on which to theorize as at the present time.

The scientific doctrines of to-day may be summarized as follows: —

The universe is of unknown origin, and all questions as to its primary derivation lead us to the "unknowable." Its phenomena proceed and persist from the action of the "natural forces of nature," which are so many modes of motion. These modes of motion are

correlated, interchangeable, and pass one into another according to the conditions of matter through which they move. The source of motion is force. This original world-force, many materialists claim to be an unconscious and insensate impulse, or impetus, forever persistent through all the modes of motion; while those more devout thinkers hold that the world-force is divine power, the will of an omniscient and omnipotent Deity, thus grafting the traditions of eld upon the science of present date.

According to either proposition — that of insentient force, or divine power — the impulse is held to be *pure;* that is to say, independent of matter, and capable of disassociation from it. Both the one and the other are thus led into logical absurdity and confusion of ideas, since it is found impossible to think of or portray *pure* force apart from matter, as launched upon it from some point or locality where no matter exists. We cannot conceive of a power disassociated from matter; and this impossibility of conception is of itself a final argument against such a premise. Hence, the present dynamic theory of phenomena, as it has generally been formulated, is rightly held to be untenable; the fact being that matter and force cannot be treated of separately, or as diverse factors of phenomena, vital or cosmic.

The confusion of concepts resulting from the pure force hypothesis, in all its developments during the last century, has brought philosophy to a stand-still, and greatly impeded scientific research.

The insufficiencies of the older dynamic hypothesis may be summarized briefly: (1) the impossibility of a mental conception of pure force, poured upon matter from a point outside of matter, every conception of such a force demanding *imprimis* a material medium

for its operation and transmission; (2) the immediate necessity of a further hypothesis as to the origin of such a force from a source, personal or impersonal; (3) the difficulty of attributing vital phenomena to an insentient force, — the mental picture being, that somewhere inside a material organism a force essentially insentient becomes sentient, thus ascribing to matter a power of transformation, such as the grossest materialist never had claimed for it; or else driven to still another hypothesis of the existence of a twin force of vital nature, which at this point associates itself with the insentient force, and thenceforth keeps it company in all living organisms.

We have here, then, three hypotheses, the first impossible of conception, and the second and third wholly gratuitous, being forced on the mind by the inconsistencies of the first; and to these we have still further to add a further hypothesis as to matter, namely, that it is fundamentally inert and lifeless.

As against this quartopartite hypothesis, the sentient theory of phenomena offers but one primary assumption, namely, that matter is not inert, but sentient, this sentience being the first cause of all phenomena. In other words, the universe is not an insentient apparatus, or a blind machine, controlled more or less perfectly by an agent outside it, but sentient in itself; and that all its phenomena are the result of its sentience, from eternity.

That the sentient theory does, in very truth, found on a lower basis of fact and discloses a law of phenomena not hitherto set forth in any scheme of nature, no one who will observe its application to physical and vital problems, thus far obscure, can long doubt. It portrays a universe acting of itself, without interfer-

ence. It presents as "unknowable," or as yet unknown, but one thing — *matter*. The sentient or vital hypothesis of the universe assumes, primarily, that matter, the basis substance of sensible nature, is creative of the universe by virtue of a single primary property — sentience.

The philosophic argument for this hypothesis is the same given for every doctrine of either matter or deity, since men first reasoned, namely, its simplicity, consisting in (1) the fact that it accounts more fully for all phenomena than any other hypothesis; and (2) that it accounts for such phenomena with the assumption of fewest unknown quantities. And herein lies all the *a priori* proof that has ever been advanced for any world hypothesis, or that ever can be advanced in evidence. We reason, and can reason on no other basis.

From the sentient property of matter, as we conceive it, goes forth the universe. The limited range of our senses enables us to view but a tiny span on the long vast octave of universal motion, a span betwixt what seems the infinitely large and the infinitely small. With aching sight and in mental bewilderment, we turn from the contemplation of heaven-broad galaxies of suns, wheeling in slow gravitative rhythm, in the abyss of space and in time which seems eternity, to the fierce white rapid swirl of gaseous molecules, too dazzling for the eye, too swift for the brain; and judge from analogy that this to us enormous breadth on the universal scale of mass and motion is but the space betwixt two notes of the vast octave; that out beyond those sun galaxies wheel yet vaster and vaster galaxies of which this one to us visible is but a molecule, and that down beneath this scorching white heat of molecular velocity, matter thins out into an ethereal tenuity to which this vibrant

molecule of oxygen is as that slow gigantic milky way in the great night sky.

Such is matter, — which ignorance has called inert, — universal matter with its wondrous sentient harmony, pulsing and vibrating, unfolding itself in forms of beauty, harmony, precision, and grace; and that our intellects perceive them as beautiful, rhythmic, harmonious, and graceful, is one great semblance of proof that the source of nature and the visible universe is also the self-same source of those intellects which thus perceive; that the same impulse which casts matter in forms to glad the eye is also the source of that eye's sensation. It is the common sentience of universal matter. It can be nothing else.

The latest word of faith from out the infinite is that *matter lives*. The sentient particles *feel*, and from this eternal well-spring all phenomena, physical and vital, move forth. Rather there are no physical phenomena in the sense of an insentient force. All motion originates from sentience; first feeling, then motion. Feeling is the primary cause and source of motion. Matter moves because it feels. Hence, in organized matter, we contemplate, not the miracle of an insentient force transforming itself into sentience and intelligence, but simply the raising-up of this primary sentience of matter to more full expression. The organism of any living creature is the instrument developed and employed by the inherent sentience of its component particles to obtain wider, fuller feeling.

The moral effect of this later conception of matter and of nature is strong and far-reaching.

It means kinship and brotherhood with all nature about us. It means love and sympathy, not only for all living things, but for earth, air, and sky, for the great

sentient environment out of which we have emerged, and a part of which we are. For it is when we are in such sympathy and co-relation with the universe around us that we live in fullest measure. Alienation is death. We die as we grow callous to the world around us, and that is a false creed which instructs to forgetfulness of earth and a direction of the heart and mind to a foreign state of existence. Such alienation is a hastening on to the apathy of old age. We are to be taught to live, not to die. It is a most hopeful fact that all the enormous falsehood which forms the burden and the shame of literature, namely, that earth is a dreary place and life a miserable bourn, has never really alienated the great warm heart of humanity from this dear old earth, the birthplace and home of all the human generations.

The earth is a dreary place only to those who from error ("sin") and disease are incapable of enjoying it; and the problem which life sets before us is, to so reform ourselves that we can enjoy it and prolong our years.

Terrestrial life is a burden only to those who live badly. It is to us what we make of it; or rather, make of ourselves. Bad living will, erelong, cause every human being to loathe life and loathe the place in which he lives. But heaven itself is at the converse pole.

II.

OF LIVING MATTER, OR BIOGEN; INTRODUCTORY.

Living matter, commonly called *protoplasm* and *bioplasm*, but better termed *biogen* (life-generator), is at once the material, and, from its self motive-power, the physical basis of animate life.

The term *biogen* has already been used by at least one eminent writer on biological subjects. It seems preferable; and if by common consent it could be adopted, a gain in both perspicuity and diction would be effected. We shall venture to use it synonymously with the phrase *living matter*.

It was long held by eminent authority, that in protoplasm, or biogen, a new force found entrance into matter; or that if this new force, life, were a mode of the universal energy, it was, in biogen, transformed from an insentient to a sentient force. That hypothesis need now no longer be either defended or attacked. It is obsolete.

Matter is sentient everywhere; yet on the terrestrial sphere, matter can move in response to its sentience only when combined in a certain peculiar way, namely, in that complex association of molecules forming the semi-fluid substance here designated as biogen. Such is the external pressure of gravity, and the tension of the electric and other modes of energy, that this biogen is the only known terrestrial substance, loose, yet coherent enough to be able to move itself at the instigation of the initial sentience of matter.

And were it possible for minds, enlightened and sane, to revert to idolatry, there is one object on the surface of this bleak, storm-swept globe of earth well worthy of incense, a bowed head, and a bended knee, — this wonderful aggregation of living matter from which all living creatures have sprung. It is at once the material and the architect of organized life; in it stirs the sentience which animates every organism and constitutes man a living being. But for this mobile substance, the earth would lie a dusty *tundra*, with no tint of vernal green on its wide gray plains or mantling its rusty precipices. The continents would stretch out bare and solitary: on them the rain would beat, but no living plant would grow. Save the lonely roar and wash of waves on desert coasts, the clangor of storms, or the harsh rumble of volcanic fires, the great convexed terraine would be a voiceless waste. In vain would spring suns caress it, or summer's passion burn, or autumn ask a harvest. Fruitless old earth, never crowned with life, would wheel onward through her era and epochs, a sphere of stone and water, dun, rugged, and mute.

Other spheres in space may, from their size and the physical laws resultant from size, have matter in molecular combination different from that on this globe; and life may have developed on a different plan. But on the earth, life in all its types and *genera* has developed, upward, from simple sentience to intelligence, through matter in the form of biogen. There is no reason, however, to believe that the matter in biogen is one whit more sentient than that in the ordinary hydrogen, carbon, nitrogen, or oxygen of which it is composed, but only that from physical law, it is, when grouped in this peculiar way, loosely bound together and mobile enough to obey the omnipresent impulse to move.

Here in this easy mobility began the grand evolution of life. But the sentience of those great masses of terrestrial matter, which from their environment cannot thus move and develop, still expresses itself in other ways, and we have what are designated the natural forces: electricity, magnetism, heat, chemical action. These are so many utterances of sentience low down in the atomic depths.

As to the constitution and physical behavior of biogen, or living matter, the following facts can be set forth: —

I. It is a colorless, odorless, transparent substance, in consistency semi-fluid, viscid or sticky, composed of oxygen, nitrogen, hydrogen, carbon, sulphur, and phosphorous particles in somewhat loose combination.

II. Under a fifteenth objective and even higher microscopic power, as high as a fiftieth, no evidence of structure can be detected in it. This absence of structure is not fully established, but is inferred from its mobility, the strong probability being that the differences in behavior exhibited by different kinds of biogen are due to varying quantitative proportions of its component elements; conditions invisible by any known means of scrutiny. There is no visible difference between biogen taken from an animal and from a vegetable; from a man or a maple; living matter everywhere appears to be the same.

III. It manifests itself as living matter by self-movement; pulsations, elongation, and projection; exhibiting rectilinear and circular motion. As long as it remains in the living state, matter is never utterly at rest; that is to say, it never ceases from self-movement, but exhibits *motion as a co-relative of the living condition.*

IV. In biogen motion is a test of life. As long as it lives it moves, and *vice versa*. Further, as long as it lives it will not decompose, rot; or, in other words, display its primary energy in chemical unions with contiguous substances. As long as it lives it gives up none of its initial energy to such unions, but remains "sweet" in the midst of substances which incite it to decomposition. On the other hand, it readily decomposes as soon as it has passed into the non-living state, when exposed to the same rot-inciting agencies. Hence, it is concluded that in living matter, or biogen, the primary energy or constant of matter is exhibited as *motion*, and hence cannot expend itself in the processes of decomposition, as is the case after passing into the non-living condition. *That the primary sentience of universal matter thus passes into motion in biogen, is the key-note in the development of life on the earth's surface, and, at the same time, a fact in evidence of the conclusion that motion, universally, is from sentience in matter.*

V. The existence of biogen, or matter in the living condition, may be chemically determined by a number of tests, notably carmine staining.

VI. From some law, resulting, probably, from the equilibrium of the terrestrial aggregation of matter, biogen lives in very minute masses; that is to say, it exists, and carries on the economy of its being from the centre of very small modicums of its substance. These little masses which constitute "individuals" of biogen, "plastids," "bioplasts," or "cells," as they have been variously named, range from a hundred thousandth to a two hundredth of an inch in diameter; but, as a rule, in organized tissues, are from a three thousandth to a four thousandth of an inch in diameter. Each of these tiny masses is a living unit, having a life of its own; and the

life of an organized animal is an aggregate of these component lives. It is probable that each of these living units, "plastids," or "cells," is alike, in turn, vastly composite, an aggregate of sentient particles of matter incalculably greater in number than the "plastids," or "cells," in the organism of a vertebrate animal; and we believe it possible to thus trace the life of an animal back to the primary sentience of the matter of which the animal organism is composed.

VII. While the organism of a man, a horse, or a dog contains many quintillions of these structural vital units of biogen, or living matter, there are infusorial creatures, having life and being on the earth, which are composed of but a single one of these units, or plastids, and which are yet in all respects as perfect examples of living creatures as the larger animals; more perfect, indeed, because simpler and existing with fewer vital *errata*. The point which we need to keep in view is that the living modicum of biogen ("plastid," "bioplast," "cell") is the structural unit of all life forms; that it is the essential part and must be the object of our study. Upon its life and fortunes depend the life and fortunes of every organized living creature from mollusk to man.

VIII. The living, self-centred modicums of biogen, which constitute vital units, absorb non-living matter from without, often executing a great variety of movements to accomplish the capture of food particles, but, in organized tissues, having nutrient matter brought to them by the blood of the animal.

IX. The vital units of biogen often develop, within their self-centring masses, sub-centres of vital action, termed nuclei, and these latter still more intimate centres, nucleoli. These are not observed in all units

("cells"), yet occur in very many, and are conjectured to result from reaction to the variant degrees of external pressure by the inclosing substance which accumulates from the process of life in all biogen.

X. In a unit of living matter when well supplied with pabulum, there is a constant stream of food particles setting inward from its circumference to its centre, and an equally constant stream moving outward. The incoming current of food, as it approaches the centre of the little mass, is transformed to biogen by the sentient impulse, or energy, of the circumambient living matter; while the outward moving stream of particles falls out of the living condition, or dies, as it recedes from the centre, and stops at the circumference, where it is deposited as non-living material to which the name of "formed matter" has been given. The bulk of all tissues is made up of this formed material, to which a peculiar distinctive appearance has been given by the character or class of the living unit through which it has passed and of which it is the life product: *e. g.*, connective tissue, muscle, bone, sinew, liver, lung, or secretory gland.

The character of a vital unit, as evinced in the product of its life processes, is a condition inherited from its ancestry, a condition which has, in all organized creatures, been maturing through immense time periods, and which is correspondingly obstinate in its permanence as resisting efforts to change its character and mode of life.

XI. When supplied with food and not too greatly restricted by external pressure or cold, biogen grows or proliferates, producing other vital units like itself. Its method of growth or multiplication by self-division is regulated by the restrictive influence of the formed

material which incloses it, and may take the method of "gemmation" or budding, in which case a bud or offshoot of the living matter forces its way outward from the parent mass; or there may be "fission," splitting apart of the enlarging parent unit; or again, gradual median constricture of the parent unit, resulting in an equally gradual division into two equal halves which immediately begin life as independent units. In proliferation, when a nucleus is present, it sometimes divides, furnishing a portion of itself for the new unit, but not always. Where two nuclei are present, one generally goes out with the new unit. No uniformity indicative of law has been observed in the behavior of either nucleus or nucleolus during proliferation, and both nucleus and nucleolus are probably incidental rather than important to the life action of a unit of living matter. There is thought to be some evidence, however, that the nuclei and nucleoli differ sexually, and that growth by proliferation results after a previous mingling of the contents of these sub-units. The point is not established.

XII. In the human and other animal organisms, the units of living matter are so closely interspersed, that in any organ, or tract of continent tissue, there is generally not a breadth of a thousandth of an inch which does not contain one or more of them; yet even then they are not, comparatively, very close together; in aging tissues, indeed, they often seem to be isolated and remote one from another. In youthful tissue, biogen constitutes from a fourth to a fifth of the bulk of the organism; in aged tissue much less, certainly less than a tenth in many instances. It is to the coagulation of biogen, after death, that the phenomenon of *rigor mortis*, or death stiffening of the body, is due. Yet certain "cells," or vital units of the organism, may survive the

death of the organism as a whole for many hours, and even for days and weeks.

As to the origin of living matter on earth we have no exact knowledge. Both in ancient and modern times there have been many theories. Lucretius taught that the constituent particles which compose it came together under certain circumstances, and that thus the beginnings of life occurred. Many of the most advanced thinkers of the present century hold similar opinions; the advocates of the theory of spontaneous generation, however, have thus far been unable to clearly demonstrate their hypothesis; the question remains *sub judice*. Most minds imbued with religious doctrines hold that the vital property, exhibited in living matter, can only have been implanted by supernatural fiat. It must be conceded, however, that the growth of scientific knowledge renders the probability of an arbitrary creation of living matter, or living animals, more and more improbable.

Growth is undoubtedly a law of living matter. This wonderful substance tends everywhere, as if from inherent stress, to increase itself in bulk, and to improve its condition. There seems, resident within it, the impulse to rise into larger life, to improve itself, to develop, and from a world-wide stand-point, to move forward, through higher and higher types of organized existence, as if to achieve some grand ultimate object.

In animal organisms the living matter displays a well-marked cycle of increase and decline. From the ovum it grows to the adult condition; gives birth to ova, then declines to its dissolution. An ovum is both the beginning and the goal of individual life. A distinguished physiologist, whose investigations form a text-book with us, remarks that "the greater part of the actions

which, looking from a near point of view at the higher animals alone, we are apt to consider as eminently the purposes for which animals come into existence, when viewed from the more distant outlook, whence the whole living world is surveyed, fade away into the likeness of the mere by-play of ovum-bearing organisms. The animal body is, in reality, a vehicle for ova; and after the life of the parent has become potentially renewed in the offspring, the body remains as a cast-off envelope whose future is but to die."

As applicable to the present estate of the human species, there is a mournful truth in this generalization. It cannot, however, be accepted as a final prediction of the destiny of living matter on earth.

But of more present interest is the inquiry as to what power supplies the impetus displayed in the growth of the ovum and its extended development in the adult animal, or man. What is this wonderful ovum which contains such great possibilities within such diminutive compass? Is it the plan of an organism merely? Or is it a *modicum* of coiled-up energy which is wholly expended only at the end of individual life? Contains it the full measure of the vital phenomena exhibited by the individual who grows from it, or can a man be greater than his ancestry?

Of the forces which cause the growth of the ovum, the most potent is probably the sentient property, previously specified, the same which in the amœba, or the white corpuscle, impels it, if a proper pabulum be at hand, to assimilation, increase in bulk, and proliferation.

Given this inherent power of sentient atomic attraction, or affinity, growth from the ovum to the adult is largely a question of pabulum. This sentient impulse

to growth in living matter is manifestly supplemented, or aided, by the stimulus which the external world affords to the growing animal, through general sensation and particularly the organs of special sense.

The size and dimensions of the animal organism, or in other words, the restrictions to its growth, have plainly been regulated by gravitation and other terrestrial conditions; so that in time well-defined types in animal orders and species have been produced through these agencies.

Biogen, in whatever organs or tissues of the animal body it occurs, — and it occurs in all and forms all, — is everywhere the same in composition and in constitution, so far as can be ascertained. The wants and necessities of a locomotive organism on the surface of the earth have, however, impelled different portions of the component biogen of an organism to take upon themselves the office of constructing different kinds of tissue, for example, connective, muscular, cartilagineous, osseous, and nervous tissue, wherever these diverse tissues are needed to subserve the common interests of the organism. Although it is impossible to distinguish with a microscope between the living matter of osseous and that of nervous tissue, it being, in both situations, composed of an apparently homogeneous substance, yet from an inherited bias, memory, taste, or mode of life, these similar "cells" will construct bone, or nerve, respectively, and that, too, when furnished with a common pabulum from which to draw material. But though thus diverse in the matter of the product of their labors, each cell or particle of biogen, whether a bone-maker, or a nerve-maker, retains its common sentience, and in this respect is a compatriot with every other cell or plastid throughout the body; as in a

community one man may be a mason or a carpenter, and another a physician or a clergyman, yet both are *men* despite occupation, and have common wants, instincts, and a common feeling of fraternity.

Thus it is that though diverse of occupation, all the millions of plastids, or rather the entire ramified mass of biogen in the animal body, is homogeneous and forms an integer from which the common sensation of the organism continuously rises in a life current along the nerves of sensation. The living matter of the animal body is the source of sensation; it furnishes the basis of life. Sentience comes forth from it continually as a stream of etherealized matter, — a "nervous ether," it may be. Every variety of organic tissue has its own variety of life and consciousness; and in the human organism we find a congeries of these variant kinds of tissue lives, the glandular, the cellular, the muscular, the osseous, *et als.* Each and all of these have their desires for gratification, and influence the mental tissue which may be termed the representative and executive tissue. Often, at various stages of organic development, the more lowly tissues, from their preponderant weight, control the behavior of the individual to a considerable extent, as in the growing child where we see the nutritive, muscular, and osseous tissues running riot at the expense of decorum. By the time adult life is reached, however, in the normal individual, this servile tissue life is generally brought into subjection to the mental tissue life; and the intellect rules the organism with a fair degree of permanence. Yet not without a grain of truth has the human organism been compared to a menagerie of caged wild beasts, liable, from the negligence or illness of the manager, to raise the howl of primitive savagery.

At the present stage of human knowledge molecular action is but little understood. The movements of "atomic" centres of matter in circles and the arcs of circles, thus constituting molecules of peculiar behavior, have been estimated rather than calculated in some few instances only. But the internal, physical economy of molecules is still a field for future exploration, and it is likely that the molecule of living matter will prove one of the most difficult to examine, both on account of its complexity and the transition from the living state to the dead state, which begins, *pari passu*, with its analysis by any known method. Till recently those who have treated of it have observed it mainly in the *dead* state, as proteid matter. In this latter condition we have learned of its constituent elements and its general behavior in the presence of chemical reagents; also, the proportions of its component parts, and the degree to which it can be alloyed, so to speak; for, considered in the lump, every animal organism may be portrayed as made up of certain alloys of biogen, though this picture is but a rude one.

	O	H	N	C	S	Ph.
From	20.9	6.9	15.2	51.5	0.3	Traces
To	23.5	7.3	17.0	54.5	2.0	Traces

is one of many nearly identical statements of analysis of proteids derived from living matter, signifying that, in general terms, proteids contain so many atoms of oxygen and so many of hydrogen, nitrogen, carbon, phosporus, and sulphur, all common elements of earth and air, and merely demonstrating that no other elements than these common ones are found in living matter.

Thus much of the "dead," but do we know anything of the living substance?

Nothing, controversialists have urged.

On the contrary, we know a great deal, enough indeed to form a rational theory and belief concerning it, as compared with other sources of human knowledge. We know its traits of self-movement, assimilation, secretion, respiration, reproduction; also its automatism. We know what it likes, what it seeks to take to itself, what it does with it when it gets it. We know accurately the agents which withstand its efforts to live, which check its vital activity, which poison it, which kill it. With equal accuracy we know the agents which facilitate its efforts to live, which stimulate it to live too rapidly, and these not only in their primary but their secondary effects. We know its behavior and conditions under the effects of each and all of the natural modes of motion.

More broadly, more grandly, we can estimate the scope of its vital exertions on the surface of the earth, through many millions of years. The records of this long struggle upward are stamped into the very warp and woof of the earth's crust. There is scrawled the handwriting of life in rude characters, not illegible, and telling always of an earnest endeavor to make the most of this great boon of sentience.

More broadly, more grandly still (in Nature's great name reverently let us say it), we can divine something as we believe of the future of life on earth and foretell somewhat of its grand consummation.

From an association of material particles, then, in which the tension of the earth permits a certain internal mobility, all organized life has arisen. For we live only through the mobility of biogen and the constant vital action resultant from it; and any change in the bulk of the globe which should cause a heightening of the

material tension sufficient to arrest the present mobility of the protoplasmic substance, or a slackening of that tension tending to greater fluidity and disintegration of it, would spread instantaneously the blight of death on all things which live. In a certain degree of coherence and stability, or rather instability of a group of sentient atoms, carbon, oxygen, hydrogen, and nitrogen, the struggle to live and get larger range of feeling began in amœboid types of life and has gone forward through many millions of years with varying fortunes, always on the gain upon the whole thus far, till the great continental areas are man-clad. A thousand differing lines of upward development have been wrought out, molluscous, vertebrate, according as the vital substance has chanced from its environment to become conditioned. At times the earth seems literally to have groaned beneath gigantic *genera* of reptilian vertebrata; and again to have been an arena of bloodthirstiness, prowled over by fierce carnivorous mammals, — creatures in which an abnormal thirst for slaughter had hopelessly predominated over every other faculty.

Meantime life was developing wonderfully, and in point of intelligence more hopefully in insect types. The ant, the bee, and associate *genera* had reached the highest point of development thus far attained, but not the most promising as regards future attainment. A branch of the reptilian family, too, incorporating aerial navigation in their physical functions, had mounted into the atmosphere and been enabled to avail itself of all earth's climatic favors and fruits, thereby considerably exceeding man with all his inventive skill, unassisted by wing power. We naturally envy the birds this their undoubted point of superiority; although wing power is probably obtained and enjoyed at a too great sacrifice of intellectual power.

It cannot but seem a chance and almost strange thing, that in one of earth's most unprepossessing species — an ugly, mean, and disgusting little beast, indeed — there should have developed a tendency to think (born of its dire necessities no doubt), and to act in obedience to thought; in a word, to develop brain tissue and mental power as against muscular. Yet thus it has been, in the anthropoid creatures and their ancestry; and thus humbly and there the grand royal line of brain, as against brawn, began its upward struggle from ape to man, and looking forward as we ardently believe from manhood to godhood. This last of the great mother's lines of vital effort on earth, hit upon in a moment of nature's despair as one might almost conjecture from the lateness of its inception, was yet to be the one of all others to wax most powerful and to conquer despite lack of natural hardihood and natural armor. For only after a thousand experiments did nature seem to discover that it was only at the expense of risking a comparatively large, protoplasmically soft and unprotected creature abroad on the rough surface of this planet, that the amount of sentience necessary to build mind and raise up intellect could be generated and sustained.

Past what catastrophes and through what unwritten ages our pre-Adamic ancestors trod the unmapped surface of now submerged continents, or wandered in barbarous poverty along the slowly emerging coasts of later lands, there is prehistoric silence. Only a few stony vestiges are found. Yet do these possess for us a fascination unrivalled and personal. Deep in the strata of the pliocene drift, beneath the slow deposits of a thousand centuries, and associate with the extinct carnivore and herbivore of remote epochs, earth's prim-

itive children, the fireless, artless "flint folk of the drift," lie entombed along with the rude stone weapons of their hard early fortunes. Their meagre story is utterly lost. Through a dateless period, compared with which the era of enlightenment is but as yesterday, the unhistoric man lingered with the brute, till in the Indian Orient, or as some hold, upon that sunken continent over the sea-buried temples of which the archipelagic waters of the greater ocean now rolls, the Indo-European, the "inspired" child of the Sun, appeared entering on his grand march to the west, in the dawn of history; beginning that triumphal progress round the world, to celebrate, it is dreamed, in the event of his course, the Apotheosis of man.

He is for this earth the historic, the political, the ecclesiastical Adam. The history of our world is his history, and in him it repeats itself. Civilization is his creature, his intellectual estate, accumulated and entailed through centuries of race life. That synonymous chain of identical language, descending from the Sanscrit to the English, is the progressive labor of his tongue. He piled the enormous architecture of Bonabe and Ceylon. He reared the gloomy grandeur of the Egyptian Thebes, the splendors of forgotten Luxor and the granitic mass of the pyramids, the sacred magnificence of the Hebrew Temple and the sombre cathedrals of the Middle Ages, ever showing the same vast constructiveness which is now displayed in railroads, iron steamship lines, and telegraphic cables.

The empires of the past, magnetically shifted from capital to capital, are but the successive households which mark his journey westward. On that broad historic belt of earth, extending from the Ganges to Britain and thence to the New World, the ethnologist and philol-

ogist find the handiwork of but one race, one man, — the Indo-European.

He is the primitive Hindu, "the free and noble" man, the speaker of Sanscrit, the singer of Vedas. He is the magnificent Assyrian, gold-robed, the imperial "hunter," served by captive multitudes from conquered cities, builder of populous Nineveh and princely Babylon. He is the sumptuous Persian, prevalent in arms, dominant from India to Ethiopia. He is the democratic Greek, the artist of passion, the elegant worshipper of the beautiful. Shining Apollo and manly Hercules are his ideals. The Parthenon, the marble temples and Phidian statuary declare the unique purity of his taste. The drama, the choral choir of Parnassus, and those pristine schemes of philosophy are the deathless creations of his genius.

He is the Roman; the Indo-European is in Italy. Austerity, gravity, and stateliness distinguish the great lawgiver of antiquity. The vision of the prophet is realized: his symbol is iron. Duration of power is foreshadowed in his character, and that durability of labor with which the still visible outlines of the ramparts, walls, and military roads of that strong old people still defy the erasure of time. Only the most terrific vices and the very scrofula of luxury could sap at last the strength of Rome. Then for a time returned the gloom of the prehistoric ages. The Indo-European had fallen from his place; the darkened world glided back toward barbarism. Sad, desolate centuries crept by; the hopeless stagnation of unprogressive races settled over Europe. The treasures of science and art seemed hopelessly lost.

But no, though fallen and terribly crushed by Hunnish violence, the persistent race life, the intellectual

spark which history first saw glow in the Hindu, was not extinct. From the ashes of Roman greatness it revived, to enlighten its destroyers. The night of Mongol violence was reillumined; a younger day dawned for Western Europe and America. We are of its dawn. We trust its sun will never set; that Apotheosis will be its achievement; that America will give, not alone empire, but immortality to men.

III.

LIVING MATTER; ITS METHOD OF DEVELOPMENT IN ANIMAL ORGANISMS.

With these general observations as prefatory, we may go forward to the examination of a notable and remarkable series of modifications which living matter undergoes in what is termed *differentiation;* modifications which are rather evinced by living matter in its products, than demonstrable by any microscopic scrutiny which we are as yet able to make. Judged solely by the products, or tissues, which biogen forms in different plants and animals, there are a great many different varieties of living matter. For example, in the wheat plant we find the biogen, at a temperature of fifty degrees, growing and extending itself by the taking-up of carbon dioxide, water and earthy particles, forming, as a result of its growth, straw and grain kernels, externally quite different from that produced by the biogen of a cabbage or an apple-tree. The product of sponge biogen is unlike that of coral biogen; that of an oyster is dissimilar to that in a fish; and fish again differs from the flesh of mammals. The living matter of a plant and that of an animal take up food particles and grow at different temperatures, producing tissues which can be very readily distinguished one from another.

We are led to inquire more intimately as to the cause of differentiation. What law, or dominant tendency of biogen impels or primarily impelled a certain tract of pure, undifferentiated biogen to take upon itself the task of forming, for example, bone, exclu-

sively? The answer appears to be that a certain stress from the biogen of all the other parts of the body has urged and forced upon the biogen of this particular tract the necessity of taking lime phosphate particles into itself, to support both itself and the rest of the mass with which it is associated. This animate stress has been interpreted to this particular tract of osseous-producing tissue largely by means of general gravity; but it has also acted further and more sentiently than from a mere imposition of weight. The biogen of each different tissue of the animal organism was originally forced to assume the office of forming that particular product by an expressed want of the whole mass of biogen of which it was a part. When once the office of such production is established, parent transmits to offspring a tendency to repeat the same processes by what is termed heredity; but originally these various tissue offices were enforced as above indicated.

We are led to inquire, therefore, what this *stress* is, and by what means a *want* in a tract of ordinary biogen is expressed to another tract associated with it in the same general mass. The fact seems to be that such a want is of the nature of a feeling of discomfort, a sense of peril or of necessity. Corresponding to this feeling there is, probably, a physical change in the arrangement of the molecules, or particles; and this physical change, or shift of minute arrangement, apparently sets in motion certain ethereal currents of matter which convey into the contiguous biogen an expression of desire which influences its mode of life. These ethereal currents may be of the nature of ordinary electric or magnetic currents — currents of an all-pervasive ether — or, as is most likely, they are ethereal streams of matter in extreme attenuation which biogen, thus circumstanced,

yields or throws off, to form what have been termed nerve currents and "nervous ethers"; and that these ethereal streams, emerging from the biogen of one part of the body and proceeding to that of another part, actually convey not alone a physical impulse, but that they import actual, characteristic particles; and that such a flux of particles is constant, going and coming from one tract of the body to another. We know, indeed, or have good reason to believe, that universal matter in the grosser, larger masses of suns and planets, emits such ethereal streams, forming ethereal oceans, as the result of their globe-lives. How much more, then, should we look for such emanations from biogen, — a form of matter in which sentience is more active!

In the animal organism it is demonstrable that the direct or reflex "sympathetic" action of one tissue upon another causes waste of energy, and occasions loss in weight. There is no more reasonable explanation of this phenonenon than that a feeling, or a want in one tissue, when expressed to another, is accomplished by means of an actual flux of matter. The deposit of hereditary traits in ova and spermatozoa points strongly to the conclusion that a current of material which bears with it the peculiar characteristics of its source flows to the generative tract from each and every tissue of the entire organism. The development in the nervous system — an apparatus for the transmission of feeling and of general inter-communication between all the tissues and organs of the body — still further confirms the hypothesis of a flux of ethereal matter, when the peculiar structure of nerves is studied. We there find both an axis cylinder of continuous gray biogen, and also insulating sheaths for the confinement and direction of the vital currents.

It is not till we come to examine minutely the organism of one of the higher animals, that the full scope of differentiation is manifested. In the body of any warm-blooded mammal — man, for example — not less than a hundred different kinds or varieties of biogen are seen to have united their products. The human organism is a congeries of different kinds of biogen, all drawing their food particles out of that complex fluid, the plasma of the blood, each selecting different kinds of material, and producing, as a result of its living, different tissues — bone, tendon, muscle, connective tissue, cuticle, nails, hair, etc. Indeed, it seems that rather than die, biogen will live in almost any imaginable form, and within the limits necessary to renew its substance, will take up almost anything in the way of food, and build itself out upon it, as a framework of support. We observe this in bone, as contrasted with muscular tissue; or in the liver, as contrasted with renal or pulmonary tissue. The necessities of the organism as a whole, during the long process of its development from a lower to a higher type of animal, — from a small mass of undifferentiated biogen to an animal body, containing a hundred different species of biogen, — have forced the living matter of different tracts in the body to adapt itself to certain subordinate uses, or, in other words, to become differentiated in various organs. In the biogen of bone, we see the living matter, from long-formed habit or inclination, taking up, in addition to the necessary particles of albumen, fat, etc., a large number of particles of phosphate and carbonate of lime, and depositing these in a certain fibrillar arrangement, on which it rests and extends itself in growth. In connective tissue we see the biogen making use of albuminous alloys in a like manner, to form the char-

acteristic products of that tissue; in cartilage, the same process to a still greater extent prevails. In the two or three varieties of nervous tissue, too, we observe the various products of differentiated biogen; and, in fact, there is not a tissue of the human organism, not even the least active epithelial or endothelial surfaces, which can be ranked as undifferentiated; that is to say, consisting of biogen in a primary or unmodified form. For we should define primary, undifferentiated living matter as biogen which takes up for food only such particles as would tend to renew it as biogen, and with no view to the production of anything like bone, connective tissue, epithelial scales, secreted fluids, or, in a word, any of those products which one acute observer has very aptly termed "formed matter."

Primary, undifferentiated living matter, or biogen, is sentient to the full extent of the term *sentience*, in that it is capable of seeing, hearing, tasting, smelling, and feeling; whereas, differentiated living matter has lost a certain degree of this sentience, more or less, according as it has assumed, to greater or less extent, functions other than those of simply existing and renewing itself. For example, there is little sentience in the biogen of cartilage, bone, and connective tissue, — little, at least, that we can be made aware of. Hepatic and renal biogen, too, appear to possess general sentience in a considerably deteriorated degree. So that it may be set down as a law, that in the differentiation of biogen and its degradation to organic and mechanical uses, it loses sentient ability, and loses it in direct proportion to the extent of the conversion of its energies to other processes than that of simply existing as a sentient mass and renewing itself as such.

This law of biogenetic existence will be found to ex-

tend far out into the sphere of ordinary human activities. If the organism of a man be condemned to hard physical labor, we must not expect to see in him the intellectual acumen of a philosopher; and always in proportion as the physical struggle for existence is harder and more severe, the less will higher exhibitions of intellect be observed. The Buddhist doctrine of the reduction of the human mind from terrestrial pursuits, pleasures, and griefs, to a simple contemplation of nature — in other words, to an unruffled state of existence — seems to rest on this deep law of the living matter within our organisms. If we make of ourselves mere machines for the manufacture of some product, we must necessarily expect to *live* and *feel* less intensely and less extendedly. For, in reality, by thus devoting the entire living powers to either hard manual work, or even mental drudgery, we still further differentiate the living matter within us from its primary, all-sentient condition.

From this stand-point of estimation, at least, the Buddhist doctrine of the *nirvana* is well worth a careful examination.

On the other hand, such is the force of gravitation on the earth's surface, and such are the material obstacles in the way of life, that it is only by differentiation of biogen in organic tissues that a continent mass of living matter can exist and improve its fortunes. The sacrifice in differentiation is therefore well made on the whole, though the disadvantages of it need to be borne in mind, with a view to their removal as fast as by dint of human exertion the earth is converted into a better theatre for life.

We are next led to inquire as to the physical nature and processes of differentiation. What happens physi-

cally to biogen when it is changed from the primary condition to the differentiated condition? What change in its structure, if any, marks its loss of a portion of its primary endowment of feeling? Under the highest microscopic power at present attainable a protoplasmic "cell," by which nothing more is now meant than a tiny modicum of biogen, is seen to be made up of a semi-fluid, viscid, colorless substance, the biogen pure and simple, with but the slightest traces of structure or arrangement. It merely contracts and expands. There is oftentimes a nucleus and nucleolus, that is to say, a "cell" within a "cell," and sometimes clear spaces which have been termed vacuoles. So far as making out distinctive characteristic differences within the primary colorless living matter itself, no power which can at present be brought to bear on it avails much, whether in bone, brain, or epithelium; for differences observed in some "cells" of bone, connective tissue, nerve tissue, epithelium, and glandular pulp are often self-contradictory when observation is extended to members of such cells. There is some reason, however, for asserting that different tissues show, in their component cells, certain structural differences. But these differences do not always conform in "cells" of the same tissue, as in two of bone, or two white blood corpuscles. It must be remembered that we are here dealing with something very minute, and that the refraction of light greatly embarrasses observation. The only assertion which it is safe to make is that there appears to be a certain slight difference in the intimate "cell" structure of "cells" from different organs of the body, and that this difference is probably connected with and the result of differentiation of the biogen to different uses. This is as far as we have advanced at present.

But while there is a strong probability that biogen, in becoming differentiated to organic and mechanical uses, loses in sentience and hence in vitality, as compared with primary undifferentiated biogen, it must not be forgotten that the apparent insensibility and low vitality of living matter in a nail, or in bone, as perceived by the personal sense of feeling, may be due to defective nervous connection between such tissues and the sensorium of the individual. In other words, the biogen of these tissues may *feel*, or *sense*, a great deal more than the person, the *ego*, of whose organism the bone or nail forms a part, knows of. It is a fact that a person knows little of the life and the ordinary sensations of many tissues of his body, particularly those under control of the sympathetic system. Of the usual life of his stomach and alimentary tract, he is but slightly cognizant. It is only when something is abnormal and quite wrong that painful sensations from these tissues reach him and then often very vaguely. The same is true of the kidneys, liver, and spleen. It need scarcely be observed that this lack of perception and the means of securing it in any case is one of the great obstacles to obtaining complete control of the organism. At best, we obtain but fleeting sensations from the actual life of many of our component tissues; the *ego* being but the pole of the self-centred nervous system, the diverse *rami* of which fail to completely and intelligibly report the actual sensations of the living matter in the tissues which they but imperfectly reach.

The general conclusion, however, remains unshaken, that differentiation of tissues implies a lowering of the sentient coefficient.

In the observation of differentiation a great many

interesting questions arise which involve animate existence to the last degree. For example, we see that in the animal organism, where biogen has become differentiated in various tissues, the state and degree of differentiation persist from generation to generation of individual animals, through periods of time which are long even in the geologic sense. Indeed, unless terrestrial changes destroy the type or race, there seems no reason to doubt that it would go on forever; that is to say, when once the differentiation of biogen to a certain series of organic and mechanical uses is accomplished, there is no inherent tendency to change this state and degree of differentiation. The only agents likely to work changes are external agents; and in the earth's physical history, telluric and climatic changes have usually destroyed rather than modified types, showing that a well-established animal type will perish sooner than re-differentiate its biogen, even to a slight degree. The higher the animal type, too, and the more complex and extended the differentiation, the more hardly is a modification of type and species effected. It is not thought likely that man would survive any considerable geological change of the earth's surface and climate.

Another interesting inquiry is one as to the length of time required, under a certain system of terrestrial conditions, to differentiate primary, undifferentiated biogen into such a series of different tissues as are observed in a fern, a mollusk, a fish, or a mammal. We do not here ask the question how long a time has actually elapsed since mammals first began to be developed from the lowliest forms of life, but how long a time would be actually required for biogen to thus differentiate itself under uniformly favorable conditions,

or under the very best possible conditions. Including all the time lost in catastrophism and other set-backs, the evolution of man from primary forms of biogen has no doubt occupied a million of centuries. But how many centuries would actually be requisite for the same process of evolution were all the external agencies which have accomplished it applied to the task *seriatim* and in the best possible order? Could the same progress upward in differentiation have been made in one thousand centuries, or a hundred? The inquiry may seem trivial to the reader; yet it is important when we are engaged in a canvass of the physical possibilities of biogen. For if a million of centuries have actually been required to work those intimate changes in biogen now observed in the human organism, then it might be fair to conclude that equal time periods would have to be expended in important modifications of these differentiations; and in general that changes in tissue differentiation would be to the last degree difficult in any individual organism. The subproblems exhibited in the study of ancestry and heredity would, on such premises, assume a far more formidable aspect. We already know that the errors of our fathers are visited on their offspring to the third and fourth generations, but are they inflicted in perpetuity? Is the ghastly dogma of eternal punishment a fact in nature, founded deep in the differentiation of biogen? Or if true, what agent can prove a "saving grace" for the washing away of sins which abnormal differentiation of the living matter has incorporated in the animal organism?

Experiments of breeders to improve animal characteristics have shown certain modifications, which are, however, rather extrinsic and quantitative than quali-

tative; and when the agents which have wrought the apparent modifications cease to act, the animal in two or three generations relapses into its former identical estate, thus demonstrating that no real differential changes were effected. So that at the end of the inquiry we are left with no better guarantee of the power of man to change himself than is afforded by the inner faith which we all possess, that it is within our power to change ourselves, if only we will resolutely set about the task.

IV.

LIVING MATTER; THE RISE OF INTELLECT.

In the human organism we contemplate a sentient mass, consisting of a hundred or more variously differentiated tracts of biogen, — a mass in which primary, all-sentient biogen has been variously degraded from its virgin condition to secure locomotion along with a great variety of mechanical and chemical functions, by the greater or less sacrifice of sentience. This degradation, this sacrifice of its sensibility to physical effects, has been needed to enable a united mass of biogen of the size of the human body to exist and make its way as an individual on the earth's surface. Nor have the sacrifice and the degradation been without fruit. Very early in the union of considerable masses of biogen into one body, and the formation from it of what may be termed living creatures, a peculiar kind of differentiation began to be needed and hence to be developed, — a tissue for inter-communication between the other tissues and organs. A nervous system began to develop and come into use, or, in other words, a certain part of the component biogen began to take upon itself the function of conveying the sensations of the biogen about it to all parts of the associated mass, in addition to being sentient itself, and hence sacrificed a part of its initial sensibility to the task of carrying sensation. Immediately then the necessity of a common centre, to which the sensations conveyed could be brought, began to be felt; and soon sub-divisions of the same carrier tract of biogen took upon themselves the office of *sens-*

ing the sensations conveyed and estimating them according as they were intense or faint; and at length of responding to them by a sympathetic movement on its own part. Thus nerve ganglia and in time a central sensorium and cerebellum were developed, and from these centres of the conveyed sensation, a motor system of nerves, as the mechanical agent for the sensory system, was developed out of still other tracts of the as yet nearly virgin biogen. Thus, at last, a kind of differentiated biogen was developed, whose office it is to deal with the sensations of all the other differentiated kinds of biogen, to convey it, to estimate it, to act for it, and finally to assume the responsibility of being an arbiter and director of its functions. Yet while accepting this regal function at the expense of a portion of its own original, raised-up sentience, it yet remains biogen capable of limited sensation, and having a sentient economy of its own; much degraded, however, in many of the large nerve trunks which are as destitute of sensation, *per se*, as are tendons or bones. But in the gray matter of the larger ganglia, and in the apparent centres of sense located inside the skull, we find biogen which seems to possess an exalted capacity for sensibility; and in mammals, and especially the human order, we discover a special development, a grand addition to the ganglionic system, in the cerebrum or greater brain. The grand sacrifices which were made of the virgin sentiences of biogen, in order to allow a large mass of it to unite together and become an animal capable of locomotion, digestion, defence, and aggression, able to see, to hear, to taste, to smell, — sacrifices of sensory powers to mechanical effects, — began at last to bear fruit in the refinement and development of biogen to the condition

of gray brain tissue, — an estate above its virgin condition, where mind appeared as a product of biogenetic life; where the component biogen is brain, its raised-up sentience, intellect, and its method of living, mind.

A grand result has been achieved: biogen has risen to an exalted degree of sentience. Let us therefore mark well the steps by which the result has been attained. First, we see a partial degradation of virgin biogen to a lowlier condition of sensibility. There is cartilage, bone, sinew, muscle; blood, liver, spleen, kidney; connective tissue, cuticle, hair, nails. By this sacrifice a certain amount of sentience was exchanged for locomotion, increased assimilative and digestive power, and the ability to secure better food; also increased power of vision, of hearing, tasting, and smelling. And it proved a good exchange; for upon this sub-structure of degraded biogen, the original powers of which had been restricted and repressed, there arose a more highly developed variety, the gray living matter of ganglia and brain, the sensibility of which is exalted or intensified by that of the restricted tissues. To the gray living matter these lowlier tissues offer a protection and a defence from the cold, rough environment of inanimate nature amidst which we live. A nidus is afforded it, in which, housed about by bone and brawn which move at its mandate, it may develop to a higher estate of biogenetic life. But for this degradation of primary biogen to the office of making bone, sinew, brawn, hide, nails, and hair, the protective, defensive, and provident advantages could never have been furnished to the tract of biogen which has developed to the condition of brain. Intelligence is as much the life of the gray living matter of the nervous system as mechanical movement is the life of muscle.

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There seems to be nothing very wonderful in the process by which the virgin sensibility of biogen has been raised to the condition of intellect. We observe, first, a condition in which a *modicum* of biogen is compelled to *feel* the *feeling* of another contiguous *modicum* of the same sentient substance. The medium or agency of transmitting *feeling* in this case is probably an actual current of material particles in a rarefied condition; an "ether," let us say, for the sake of a familiar word. Excited to vital action by this received sensation, it transmits the sensation to another contiguous "cell"; this latter in turn transmits it to a third, and so on to centrally located tracts. These centrally located tracts of biogen, which have had this magisterial office thrust upon them by the importunity of their fellows, find themselves the recipients of confided sentiences from without, on all sides. They are stimulated by it and forced to respond sentiently, by like ethereal currents of their own substance, it may be, to these incoming stimuli, and respond most decidedly to those outward tracts which send in the most vigorous currents. Forced thus to act from the very nature of biogenetic life, the faculty of discrimination and of judgment as to the nature, character, and motive of these incoming currents of sensation is in time developed. It is the sentient perception of being a centre of incoming currents of sensation from outlying tracts of biogen which produces the sensation of self-consciousness. It appears to be nothing more nor less than the perception on the part of a sentient tract of biogen, that sensations from without it are sent in from every side, and that it, perforce, is made such a centre by the pressure of incoming sensations which meet and confront each other within its sentient substance. The transmission of sensation in-

ward to a central tract, and the necessity forced upon that inner tract of auditing and taking cognizance of those sensations, explain the resultant sense of self-consciousness, the *ego;* nor does there appear to be anything mysterious in the manner of it. There is, indeed, but one mys'ery in the universe — matter. Nor does there appear to be any intrinsic difference betwixt the sense exhibited by a single "cell" of living matter and the brain of a Napoleon or a Webster. The human brain is but a quantitative development of living matter favorably situated and having an environment of variously differentiated biogen which serves it in the process of its development. For in this process of development there is perceived to be only a continuously and more extended repetition of what took place in the formation of the simplest type of a nervous system in lowliest forms of animal life.

The brain is a larger and more elaborately developed nerve ganglion, — ganglia such as may serve low types of animal life as a brain, and such as are scattered throughout the human organism, as sub-centres of nervous action. All these ganglia probably possess a certain degree of self-consciousness, although this sensation, except very faintly from a few organs of the body, is not separably transmitted to the central seat of intelligence with sufficient strength to be perceptible to the individual. Nevertheless, the cerebrum has become a head-centre, so to speak, for the reception and estimation of sensations from all these sub-centres, and of final decision and judgment concerning them. First, there appears to be simply a perception of feeling conveyed from the differentiated tracts of biogen to these sub-centres, a perception which is in part estimated at these sub-centres. Thence the partially

estimated perception is transmitted on to other ganglia, till it finally reaches the head-centre. The gray living matter of the brain has thus been made the repository and agent for the estimation of a thousand simultaneous currents of these partly-interpreted sensations, transmitted to it from all portions of the organism, and particularly from the organs of special sense, the eye, the ear, the olfactory and the gustatory tracts; as also of direct sensation through certain nerves of general sensation. Thus impressed into the service of the organism, it has developed in size to become adequate to that service. Instead of a tiny ganglion for the receipt of simple sensation, we have in the human brain a grand mass of gray living matter capable of receiving and estimating the perceptions of a hundred inferior ganglia, of comparing these perceptions with other previously recorded perceptions from the same organs of the body and with those from other organs; of deciding as to the relative importance of all these and of responding through the motor system of nerves, in accordance with conclusions which are arrived at after a final estimate of the grand total of perception, reflex perception, and the thousand-fold perception of perceptions which make up the compli cated process which we commonly call *thinking*.

Broadly, the brain and nervous system of man is the ultimate result of the differentiation of biogen to the necessities of terrestrial existence. In this refined tract of gray living matter resides the intellect and all which constitutes man as distinguished from the humblest form of life. Here is the "soul" of theology. The intellect is in proportion to the amount and excellence of the gray living matter; and by the same standard a man has more "soul" than the lower animals. We know of no other standard of comparison.

The causes or agencies which have led to this great development of gray living matter along the spinal axis and in the brain of man may be described as agencies which have acted constantly and for many hundred centuries to put this gray matter into more intimate and full relation with the whole universe of matter about it; in other words, to establish the broadest sentient connection between this favorably located mass of sentient gray matter and the external world. To feel and perceive external matter is to obtain knowledge of it. All knowledge rests primarily on a basis of sentient contact of living matter with external matter. Such knowledge comes to the gray living matter of the human nervous system and brain through the organism in which this nervous system is developed. The organism moves amidst matter external to it, and from contact, perception is experienced, recorded, and hence remembered. When once the faculty of memory and comparison is developed in living matter, the processes of thinking and of reason may begin, and imagination seems to be the next step in extension of these processes.

When the development of the living matter has advanced thus far, it becomes possible to derive knowledge otherwise than from contact and general sense. We can reason from the analogy of previous sensations as remembered. Language becomes an agency for the communication of the perceptions of our fellow-beings. By virtue of the faculty of memory and imagery we are able to experience the sensations of our fellows. Written and printed symbols representing language come into use, and out of the recorded sensations of others in script or print we can still further extend our range of sentient experience. Devices for amplification, like the

telescope and microscope, increase the natural power of the eye to receive impressions from external objects, and enlarge our perception of the universe. By locomotion and travel, too, we come in contact with wider areas of terrestrial territory.

It is from all these means and methods of gaining perception of surrounding matter, animate and inanimate, that a human intellect is established and a human brain developed. It is, when summed up, the getting into sentient relation with the universe that constitutes intellect; and the brain is the instrumentality of it, without which it could not be done, and without which it cannot continue in existence; for it is from our final perceptions of all these acquired perceptions and perceptions of perceptions that our ideas of truth, beauty, right, and duty, which form the guides to our lives, our "morals," are derived, and remain more or less constant. More or less constant, for fresh acquisitions of perception may lead to change of these ideas. The whole structure rests upon the initial sensibility of a modicum of living matter, or, more broadly, on the primary sentient property of all matter, whether in the condition of biogen or not. On this planet biogen is the condition of matter in which the self-motion of matter begins. Every "atom" of matter on the earth, whether in rock, water, or air, is alive, in the sense of being potentially sentient. But it is only when combined in the peculiar arrangement of biogen that it can begin to change sentience into motion, and shift its position to attain one more restful or satisfying to its sense of comfort. To that end "the whole creation groaneth and travaileth" to get in fuller, more intelligent connection with other matter. A "cell" of biogen has, by virtue of the sentience of matter, the power of acquiring knowl-

edge of other "cells," and of matter not in the living state. It rises in intelligence in proportion to the amount of such acquired knowledge. The reception of such knowledge increases its receptivity, and stimulates it to growth. Knowledge of the external world is a stimulus and a source of vital supply. Such received knowledge develops biogen by a process which is no doubt accompanied by physical movements and readjustments of the living substance. Every "cell" or plastid of living matter has the capacity of acquiring knowledge of surrounding matter, and thereby increasing the excellence of its material structure as a receiving medium. The latter process of material development appears to be set in motion and to go hand in hand with the reception of new perceptions of the external world. The human brain has been thus structurally increased, and its sentient condition thus heightened *pari passu*. It is on a large scale what we have instanced as taking place in a single cell of biogen. The process appears to be one of action and reaction between it and external matter, and the human organism, as a whole, has furnished the medium for the process, — a better one, yet only relatively better, than that observed in other animal forms of life.

Since we find no exhibition of animal life and personality save through the substance which we call biogen, we are led to the conclusion that, on the earth, this substance is the only medium of such life. And as we find the degree of intelligence constantly proportionate to the excellence of the organism as a whole, we are led to believe that organism is as constantly correlated with intellect; that these factors are indissolubly linked together; and that one cannot be predicated in the absence of the other.

V.

LIVING MATTER; THE CAUSES OF THE DECLINE OF LIVING MATTER IN ANIMAL ORGANISMS; OLD AGE; DEATH.

Thus far we have treated of biogen and the development of organic life as the result of a certain method of its growth, and in so doing have presented only what is held to be fairly well established science. We have now to consider the descending limb of organic life and seek causes for the decline of biogen in animate organisms, and are now obliged to enter on comparatively new ground where many strange new facts are coming to light — facts destined to revolutionize human opinion. The subject is one fraught with grave interest and solemnity, and has in it the elements of hope and fear.

From the cradle we have been taught to regard death and the dissolution of the human organism, after a certain not greatly variant "lifetime," as occurring from a fiat of the Almighty Power, or more liberally, as resulting from the action of an ultimate law of life.

In like manner, we have contemplated "old age" as a condition of the organism which inevitably approaches, due to some such ultimate law, which no effort on the part of human power can by any means withstand or greatly delay.

Fifteen years ago, when the real significance of the great doctrine of the immortality of the human soul first impressed itself upon the present writer, and the truth concerning the doctrine became apparent, that

this grand hope of men, dawning slowly yet brightly through the primitive savagery of our race during the last ten thousand years, *was an aspiration and the harbinger of an achievement to be wrought out by man himself, for himself*, these two popular conceptions of death and "old age" presented themselves for serious consideration as being of the character of insurmountable obstacles. For if the current opinions touching the cause of death and "old age" were correct, then whoever should attempt the work of prolonging his life beyond the "appointed time to live" would but find himself in conflict with natural law, or divine ordinance.

The question then arose, Are these common opinions well founded? Does the human organism "grow old" and die from any such ultimate law of nature, or edict of God? If not, what are the causes of "old age" and death?

It seemed important to seek answers to these questions; and an inquiry, embodying a long series of minute investigations, was instituted solely to this end. Certain of the conclusions arrived at are outlined, albeit in a somewhat desultory manner, in the following pages.

It would be useless to pretend that recent biological discoveries do not, or need not, affect a person's religious views. To profess "agnosticism" in the face of what we at present know of the life and the intellect of a human being, is simply a subterfuge to avoid becoming a target for animadversion. It is no doubt a graceful method of disclaiming the moral responsibility of one's scientific views; and it may be politic in the investigator; but it is none the less a shirking of the moral obligation which the discovery of truth entails upon the discoverer. Biology does involve many

religious doctrines to the last degree. Nor do I believe that the theological body will esteem that biologist less who avows the opinions touching religion which his science yields him, than he who flies the agnostic flag and feigns neutrality. God can doubtless endure all the truth which man can discover. While on the other hand, if the conclusions which biology points to, be ill-founded and not correct, there is no surer, swifter way of demonstrating the error than by announcing them and subjecting them to the test of counter-investigation. The microscope is free, and as much the instrument of the theologian as the biologist.

It is but right to state that biology has no facts in support of the Zend-Avestan doctrine that the intellect or "soul" of a human being is immortal *under nature*, after the death and dissolution of the organism through which it has been raised up into conscious existence. The *natural* immortality of the human soul, however, is a tenet rejected by several Christian sects and not taught in the Old Testament scriptures. The faith that a pitying Deity, through the agency and grace of his Son, interposes at the supreme hour of man's mortal anguish, to rescue and save his soul from unconsciousness, is not thereby affected, but rather sustained from the logical point of view. The drift of the scriptural narrative is to the effect that salvation through Christ is from divine pity in view of man's mortal condition. This is both the Old and the New Testament idea. A great sacrifice is determined on for the purpose of rescuing man from his mortal fate under nature. Biology does not raise this question of divine rescue from death, does not touch upon it, and has no data concerning it.

But the doctrine that the souls of men have been saved and are still saved by divine pity and grace can

hardly be argued as forbidding men to ward off physical death as long as possible.

Just as the human organism is composed of an association of different varieties of biogen, seen in the different kinds of tissues, *e. g.*, muscle, bone, connective tissue, skin, gland tissues, liver, spleen, pancreas, cartilage, epithelium, eye, ear, nerves, and brain; so the human life is a union of sensations from the biogen of each and all these tissues. For every tissue of the body may, in strict truth, be said to have a life of its own and to contribute its quota of sense to the sum total of a human existence; and the reason why there has never been given a perfect or even a fairly correct definition to the human intellect, or "soul," is because those who have attempted such definitions have made the mistake of regarding the intellect as a unit, resident in some particular part of the organism; whereas, it requires every part of the organism to make a human being, in the full sense of the words *life* and *intellect*. For although a leg or an arm may be amputated from the human body and life and mind continue in the trunk, yet it has none the less lost from its fulness of vitality; and if one of the component halves of the organism be paralyzed, there will remain but a feeble half of a human intellect: this statement without prejudice to the well-established fact that the nerves and brain are the tissue of self-conscious life, the axial or capitally located centre of which is within the cranial cavity. But to life and intellect the living matter of muscle, connective tissue, epithelium, and bone are necessarily component as well as that of nervous tissue. The biogen of muscle contributes very largely to our knowledge of gravitation and mechanics, as well as furnishing constant incentive to activity. The biogen

of bone adds firmness and steadfastness to character; and that of the digestive tract contributes the woof of feeling to all our ideas of the chemical properties of matter. The biogen of the olfactory tract has a largely determining influence in our conceptions of the qualities of environing matter; and the same is true of the living matter of the buccal cavity. The biogen of the retina possesses well-nigh autonomy from its special relation to and knowledge of the external world; and in minor degree the same assertion may be made of the specialized epithelium of the auditory tracts. The glandular tissue has a distinctive and important influence on the emotional side of character; the skin, too, has a constant voice in what may be termed our instinctive opinions of things.

To sustain a human intellect at full, normal tension, every co-ordinated tissue of the organism has need to be healthy, normal, and replete with living matter, or biogen, which is properly nourished and in a condition to grow, *i. e.*, proliferate normally. By growth in this sense an extension of organic dimensions beyond the normal type is not contemplated, but a constant increase and renewal to meet the waste of daily life. To properly condition the biogen of tissues which have reached their normal size and extent in the organism, as at the age of thirty years, for example, so that waste shall not exceed growth, and so that the living matter shall not be displaced by the *débris* of the life processes, is one of the difficult problems of vital physics; but a problem, nevertheless, to which the attention of biologists will be respectfully called as soon as a series of investigations and experiments, now being conducted, can fairly be pronounced on.

The question which many friends as well as skeptics

ask, is, What will be the vital phenomena when the tissues of a person sixty years of age are renewed so as to present the full, rounded, fresh appearance of those of a youth of twenty years of age? What will be the effect on the intellect as well as on the body?

Without attempting an explicit reply, it may confidently be predicted that the "tired feelings" of age, which result from illy-nourished and diminished biogen in the tissues, will give place to the buoyant, joyous sensations of youth, and that this youthful buoyancy will be tempered and guided by the wisdom of threescore years. The renewed muscular sense will again strongly prompt to activity. In the digestive tract there will be restored appetite, avid and urgent as at twenty. The special senses will resume their pristine keenness of vision, hearing, taste, and smell. The emotions will return to the apathetic organism, yet be curbed by the store of sixty years' knowledge of the world; for the stores of experience, wrought into the brain, would not be obliterated, at least not in great part, by rejuvenation. But the warm sunshine of youth, health, and vigor would fall, like a blessing from kind nature, on the aging one, and transform the whole earth for him to a scene of attractive beauty.

I am aware that of late certain writers of the *genus* pessimist have seized on this new idea of biogenetic renewal, and, with raven croak, attempted to portray the misery to the individual and to the world that would result from a successful attempt to rejuvenate human beings and ward off death. Such sombre essays are merely reiterations of the dismal fable of the "Wandering Jew," adapted to modern times, and not worth serious refutation. Do the authors believe that such prognostications will deter a single human being from

becoming young again, if he can, and living as long as possible? The warm human heart has no place for doctrines of that tint.

All the tissues of the organism have their desires, wants, and necessities, expressed from the constituent biogen within them to the sensorium of the nervous system, and all these sentient desires and wants go to make up a human life. These wants and necessities, most keenly felt in the child, impel it to physical activity; and growth results in the mobile, yielding organism up to the type limits, largely according to an inherited bias and plan, received in the embryo from the parent. There is co-ordination of tissues and of tissue-life to form an individual organism and an individual life, a "one composed of many" factors and parts. But organic life is a physical process carried on by means of and in the midst of matter which constantly obstructs it. From the ovum we struggle with an oppressing load of matter which under bad conditions crushes us at once and early in the contest to live, and under ordinary conditions brings our lives to a close within a century. We develop to the type limits from an inherited stress to accomplish a certain cycle of sensory experience, in which reside the joy and the happiness of existence. But immediately, even before the organic dimensions are reached, the work of organic deterioration and marring has begun, from the imperfections of the vital process and terrestrial accidents of manifold character. These inquiries harden, thicken, and cicatrize our tissues, and as a result we grow callous to vital stimulus from the external world. This hard experience of earth disenchants us of life, on account of the pains, thwartings, and disappointments which incidentally occur in every effort to gratify our

desires after happiness. Hence apathy succeeds to experience; and the sense-hardening, or encysting of the sensitive living matter in all our tissues, goes hand in hand with a slowly settling cloud of indifference to life. But knowledge, particularly those accumulated stores of knowledge from the life of the entire race, enables us to avoid many of the pains and disappointments of earthly life, and hence to avoid the disenchantment and apathy of advancing years. Under the application of accumulated, inherited knowledge the length of individual human life has been doubled, trebled, and quadrupled since the days when our anthropoid ancestors fought out their hard lots on the early continental areas. Vast stores of human knowledge, too, lie in stock not utilized for this purpose; nor have the minds of men as yet been turned in this direction, on account of erroneous doctrines touching death. But what we now hope and believe is, that by the application of science, particularly certain recent discoveries in biological science, under guidance of correct ideas, the causes of the vital shrinkage and decline of the living matter of the organism may be removed to the extent of effecting a revolution against the long reign of death. We confidently believe that we possess science which needs but practical application to extend the length of human life from threescore and ten years to three centuries.

Let us examine somewhat more in detail the actual phenomena of old aging, excluding for the time being the consideration of death as a result of physical accidents of the grosser kind, all of which are known to be preventable.

To the unaided eye, the body of a child presents a different aspect from that of an aged person, and, gen-

erally, there is a corresponding difference in physical phenomena. Instead of the active, sensitive body of the boy or girl, abounding in juices, elastic and mobile, we behold, as a rule, in the aged, rigidity, induration, discoloration, and the general condition of decrepitude. What is the cause and nature of this marked change? In seeking the answer to this question, it may be well to examine the different tissues which form the body, *seriatim*. First, let us look to the bony skeleton of the body. Ossification, or bone formation, begins early in fœtal life, not later than the eighth week of embryonic existence, and goes steadily forward, till sufficient earthy material — chiefly phosphate and carbonate of lime — is incorporated to insure their safe and efficient use as levers and columns for the mechanical movements and support. If the process of the deposit of these earthy salts would cease here when this limit of safety and necessity was reached, the approach of rigidity would be spared us. But unfortunately it does not. The composition of bone in an adult of the age of twenty-five is, on an average, about as follows: —

Organic matter (gelatine)		33.30
Inorganic matter	Phosphate of lime	51.04
	Carbonate of lime	11.30
	Fluoride of lime	2.00
	Phosphate of Mag.	1.16
	Soda and Salt	1.20
		100.00

In the bones of certain aged persons, this proportion is not much changed; or, in other words, some elderly persons have bones not greatly deteriorated from the normal condition of adult life. These individuals are exceptions, however, not the rule. The rule is a larger and increasing amount of the inorganic, brittle matter.

The anatomist Gray, reviewing certain researches on the subject, remarks: " . . . Thus in the child where the animal (organic) predominates, it is not uncommon to find, after an injury to the bones, that they become bent or only partially broken, from the large amount of flexible animal matter which they contain. Again also in aged people, where the bones contain a large amount of earthy matter, the animal matter being at the same time deficient in quantity and in quality, the bones are more brittle, their elasticity is destroyed, and hence fracture takes place more readily."

This remark on the brittleness of the bones of aged persons, however, should find a place; such brittleness of bones as is evinced in the fracture of the neck of the femur, from a fall, in an old gentleman or lady, can by no means be ascribed wholly to frangibility from undue increase of earthy matter. Such brittleness has a deeper cause in the less firm and continent texture of old bone, as compared with that of earlier life. A secondary cause, too, of such frangibility is due to the absorption of compact tissue in the external walls of the bone shaft, due either to diseased conditions, or disuse of the bone as a lever and standard of support. The undue use of the cane in aged persons often conduces to this latter result.

I am aware that Dr. Gardner, in his treatise on longevity, has disputed the fact of an excess of earthy salts in the bones of aged persons. It would seem, however, that the instance which he cites in proof of his position must clearly be referred to exceptional causes rather than to the actual condition in the average of cases. Such analyses as we have been able to make present figures almost exactly the reverse.

At birth the bones of the infant are not sufficiently

ossified to meet the exigencies of locomotion and terrestrial life generally. The epiphyses of the bones are still unossified and many of the bones only partly ossified; and for many years there is still enough flexibility and expansibility to admit of growth.

Ossification, too, must never be regarded merely as a deposit of lime salts in osseous tissue. A bone, like the trunk of a tree, is the result of a certain well-defined system of growth; and so long as a bone is healthily growing, there is little danger of any excess of earthy deposit in it. It is only after that bones have ceased to grow, and the normal quantity of biogen is diminished in them, that earthy matter tends to remain unabsorbed. To this tendency of the biogen to be crowded out, must always be added *that tendency of the living matter itself to cease from its function, having performed its design of rearing the bone to a certain size and form.* The tendency to cease from function, exhibited by the living matter in a bone, is correlative with the tendency in man, considered as an animal, to take less interest in life, and to grow indifferent in mind to earthly pleasures and effort, after that he has reached adult life and experienced the pleasures of existence. It is the cycle of vegetable and animal life, and natural to the lower orders of organisms.

After the estate of adult life is reached, the bony skeleton, with its attachments, erelong exhibits a more rigid ossification; the disks of cartilage betwixt the vertebra shrink, or become impregnated with calcareous matter; the stature is diminished; there is lack of elasticity. The sutures of the cranium are found unyieldingly united and the brain incased in a solid box of bone. The cartilages of the sternum and ribs harden and turn to bone, and respiration is less free; so of the cartilages

of the larynx, with restricted vocal power. The loss of the teeth leads to changes in the maxillary bones and senile alteration of the face. The ligaments and cartilages of the joints stiffen from earthy deposits in them; the freedom of action is fettered and lost; awkward, restricted movements take the place of the graceful, elastic motions of youth. Two factors of this decline and decay are here distinguishable: torpid and lessened function of the living element in the tissues, going hand in hand with non-absorption of the earthy inorganic matter with which life, as we live it, constantly struggles.

Let us next examine the flesh, — meaning the muscles with their sheaths, tendons, and connective tissue. After that the period of adult life is reached, particularly when physical exercise is much abated, the muscles are soon found to shrink in size and grow less flexible; the rapidity, as well as the power of contraction, diminishes. Examined microscopically, the fibres are seen to be smaller than in the prime of life, less deep-red in color, and often verging on a gray or yellow hue.

From a corresponding decline in the nerve-system, the muscles now receive less *stimuli;* they respond less readily, too, to the nerve influence. There is an arid condition which we speak of as juicelessness. The tendons, aponeuroses, and often border portions of the muscle itself, become in aged persons, or in some diseases, infiltrated with calcareous matter. There is a stiffening of the parts, strictly corresponding to the subjective sensation of rigidity, exhibited and felt by the person; and there can be no doubt that this condition is the true cause of the "old and stiff" feelings experienced by the aged. It is brought about by the action of the same factors as have produced osseous old age. If a given weight of muscular tissue, taken from the organism of

an aged person, be compared with a like quantity from the body of a young person, both having been subjected to heat sufficient to drive off and consume all the organic matter, the former, as a rule, will be found to contain more earthy matter, or ash, than the latter; in some cases double as much. The more marked the discoloration and apparent induration, the greater the relative per cent of earthy matter, showing that the observed condition corresponds strictly to the chemical results of analysis. What is thus demonstrated for muscles holds true of connective tissue, though the latter is more effected by gelatinous deposits.

In the vascular system, embracing the entire apparatus of blood circulation, we observe still more striking results which seem progressively developed as the estate of "old age" creeps upon the individual. Lest the reader be inclined to deem the condition exaggerated as a recent deduction, the opinions of certain standard authorities may be cited. Cooper remarks: "About the age of forty, and still more so as the age of fifty is approached, the sanguineous circulation becomes more and more languid, particularly in the veins. Hence the frequency of various congestions and visceral obstructions, with various diseases depending thereon, particularly hemorrhoids, bilious derangements, bilious and gastric fevers, etc."

Copland, in his medical dictionary, speaking of the arteries, observes: "The ossification of the arteries has been ascribed by many authors to slight chronic inflammatory action. The experiments of M. Royer and M. Cruveilheir seem to confirm this inference, as an occasional occurrence at least, particularly in the fibrous and cartilaginous structures, increased vascular action of these structures, artificially excited, being generally

followed by osseous depositions; but in a number of cases, particularly in those where the deposit takes place in the cellular tissue, no inflammatory action can be detected previously to this change; besides increased vascular action frequently exists without being attended by ossiform depositions. This lesion cannot, therefore, be altogether ascribed to this cause, although frequently resulting from it in a certain order of tissues. It would be correct to consider it merely as a consequence of disorder of the natural process of nutrition and secretion. . . . But to what cause is this disorder of the nutritive function to be imputed, particularly when it occurs in parts which have not evinced any sign of inflammatory action, as in the cellular tissues connecting the internal coats of arteries. The importance of this inquiry may appear from the very great proportion of persons in advanced years who are affected in some organ or tissue with this lesion, and from the remarkable part it performs in the production of a number of diseases of the most dangerous description."

Speaking more particularly of the arteries of the brain, Copland observes: "The arteries most commonly found ossified are the internal carotids and the basilar; but the Circle of Willis and the vessels departing from it, as well as the arterial ramifications which appear between the convolutions and come out upon the surface, often participate more or less in this morbid state. Cartilaginous degeneration is still more extensive, and seems to precede the ossific deposits. Cartilaginous and ossific formations in the coats of the arteries of the brain occasion irregular distribution of the blood and interrupted or imperfect supplies of this fluid to some parts of the organ, disposing to aneurismal dilatations, to rupture, and consequently to the production of apoplexy and paralysis."

Copland again remarks of the vascular system: "Ossification occurs only in the arteries; it occurs in them frequently and to a very great extent, particularly in advanced life."

By ossification the author merely means deposits of lime salts resembling bone.

Dr. Hooper observes of the vascular system: "After the age of fifty the walls of the blood vessels are very liable to degeneration. The aorta, in particular, becomes dilated, the elasticity of its walls impaired, and its inner surface roughened by large, irregular, whitish elevated patches of morbid matter, lying immediately beneath a superficial layer of the inner coat, and composed of a mixture of earthy and fatty matter. . . . In the smaller arteries the ossification proceeds much more uniformly, and they become at last more or less completely converted into smooth bony tubes. The capillaries are equally liable with the arteries to degeneration. . . . The cerebral arteries of old persons are frequently found studded with cartilaginous and osseous laminæ."

The French and German savants and physicians as a rule agree well in their testimony to the existence of this condition of the vascular system, including the lymphatics, and there can be no doubt that this is the usual state of these tissues as "old age" comes on.

The respiratory organs exhibit the effects of advancing age and of the frequently impure air from which it is their business to extract oxygen, most markedly in discoloration. In infancy the lungs are of a pinkish hue, which progressively changes darker, till in the adult and in aged individuals they often become a dark purplish slate color. Certain trades and crafts, for example, that of stone masons, and others whose avoca-

tions expose the pulmonary tissue to air laden with gritty particles, as of granite or sandstone, often exhibit, at death, lungs so stored with grit as to be difficult to cut with a knife. Inorganic dust of all kinds and chemical gases leave corresponding effects in the lungs after certain well-defined periods of exposure, and the ordinary discoloration, save that part of it due to blood congestion, is probably a progressive condition, the result of the general impurities of the atmosphere in which we live.

Further, the air cells and bronchi become in many cases dilated and toneless from atrophy of the living element of the tissue. Still further, there is found the same condition of the blood vessels supplying the pulmonary tissue as is observed elsewhere in the organism; and it becomes a grave question how much of the general atony and shrinkage of the lungs is due to this cause alone which so closely affects their general nutrition.

The heart suffers along with organs of less importance, from impeded nutrition, occasioned by obstruction and calcification of the coronary arteries and arterioles. The trunks of the former not unfrequently exhibit calcification, visible to the naked eye, in their walls; and in general, a given weight of cardiac tissue, taken from two individuals, one young, the other elderly, will show an excess of earthy matter in the latter, corresponding to a diminished quantity of biogen. From the gradual clogging of the capillaries the muscular fibres of the heart are imperfectly nourished, and, as a result, shrink and grow pale in color. As a general result of all this, the central cavities of the organ are dilated from the constant surge and pressure of the blood within them. The valves at the orifices of the

cavities very often undergo either cartilaginous or calcific alteration, frequently showing deposits of lime salts in laminæ. The entire organ, thus impeded and structurally weakened, fails to perform its function as formerly; and hence blood is propelled to the outlying tissues and organs of the body with less power and efficiency than in early life. This lack of power at the heart still further increases the tendency to inert deposits at the periphery, and the non-removal of formed matter.

The Brain. — As a rule the skull and cerebrum in Caucasians increase slowly in size up to the age of thirty-five or forty. There is said by some French writers to be a gradual decrease in size and weight from that age onward, at the rate of about one ounce for every ten years; while the cerebellum shows little or no change.

Of all the tissues of the body, the brain, spinal cord, and nerves (the gray matter of these tissues *par excellence*) are the last to yield to the encroachments of disease, or submit to displacement. The organs of intelligence seem to suffer more from the failure of their supply vessels than from other causes. Atrophy of the cerebrum, spinal cord, nerve trunks, and ganglia, from this cause, appears after the age of forty-five, as a rule, and is progressively exhibited, particularly in the cerebrum, in a shrunken condition of the convolutions, and even, it is claimed, in lessened numbers of the minor convolutions. As to the framework and investing tissues of the brain, the *dura mater* is often, in aged persons, seen to be shrunken and wrinkled, sometimes thickened and hardened, with little fluid beneath it. Calcific deposits in its texture and on the arachnoid surface are not infrequent and appear to be a usual concomitant of "old age"; and are quite as likely to

have been gradually formed, as periodically from inflammation. Hardening and thickening of the arachnoid membrane generally accompany the changes above cited in the *dura mater*. Often there is aridity and a crumpled aspect of the membrane, with, more rarely, calcific matter deposited, giving a sense of grittiness when taken betwixt the finger and thumb. The membrane lining the ventricles, too, shares in the generally thickened and toughened, indurated and stiffened condition; and the choroid plexus is, as a rule, discovered to be in a varicose state.

In the liver of an aged person there is often a partial failure of the proper twofold function of the organ, namely, that of vitalization of the blood by the elimination of certain crude elements which enter it with the chyle, and that of secreting bile to aid in the digestive process. We are not now speaking of diseases of the liver, but of the aging of the organ. Early in life there are rarely any diseases of the liver.

The essential elements of the hepatic tissue are the "liver cells," so named, each of these being an ordinary "cell," or modicum of biogen, such as form the vital basis of all tissues, but in this case somewhat modified or specialized for the performance of their peculiar office. If a lobule of liver from an aged human subject be microscopically compared with a similar lobule from a child or young person, the substance, as a rule, will be found more friable and harder in the old subject; while at the same time, the whole organ will appear to be more congested with blood, — a result, no doubt, of those obstacles to the passage of the blood through the organ which the brittle and hardened condition implies. If the same portions of tissue be incinerated, that from the aged subject will be found to

contain more ash than that from the young subject. From an accumulation of earthy matter in the substance, and particularly in the walls of its blood vessels, the capacity and elasticity of the organ, as a strainer and eliminater of crude substances from the blood, have been diminished. Any sudden increase of blood sent to it, as from a too hearty meal, greatly congests it, and may lead to much distress, the blood being dammed up here and backed into the portal vein, causing distention of the veins of the abdomen, flatulence, and grave disturbance of the stomach and bowels. From the gradual failure of the hepatic function, too, fatty matters are not well emulsified by the bile, the latter being scanty in quantity and changed in quality, and hence are not well absorbed by the lacteal vessels of the intestine. The same failure of function in the pancreas gland also affects the emulsification and absorption of fats, — a failure due to the same or similar structural changes in that organ. The observations cited from the liver and pancreas are not without a parallel in those made of the spleen and other lymphatic glands of the body, though with certain modifications. Induration in age is the fact here discernible.

In the case of the kidneys, too, there is a correspondence, well marked, with those changes observed as taking place, as age advances, in the lungs. It is not to these gradual tissue-changes, however, that the many constitutional diseases which manifest themselves through the kidneys, in abnormal urine, should be referred; since these are often induced by functional failure, or disturbance, in other parts of the body.

The *skin* exhibits the results of aging more readily than other tissues, being very patent to observation.

What takes place here as a result of aging may be summarized as a gradual thinning-out or elimination of the biogen from the derma, corium, and deeper sub-cutaneous layers. Both the epethelial "cells" and the connective tissue "cells" in time, as age advances, are lessened in numbers, and, in the case of the latter, evince a tendency to bring forth an altered product, seen in aridity of these layers and deposits of gelatinous matter, impregnated with various pigmentary and earthy matters. There accompanies these changes an alteration of the plexuses of minute blood vessels supplying the sub-cutaneous layers, which may be likened to the difference between the twigs of an old stunted tree and those of a young vigorous one; to wit, larger for their length, much less numerous to trunks of the same size, and dry, stiff, and thickened in their coats. Hence it follows that the blood permeates these tissues far less evenly and thoroughly than in the youth. The tissue itself is less permeable, from fibrous, gelatinous, or earthy matter; there is less living biogen in it than formerly to be nourished; and the vessels bringing blood for its nourishment, from obstructions, thickened walls, and less cardiac power, have grown shorter and stubby. The larger trunks are often varicose.

As the organism encounters the wear of advancing years, the muscular walls of the stomach are observed to lose their sensitiveness and power of contracting upon food. The tissue has thinned out, too, to a considerable degree. The peristaltic movements are less strong, and all the secreting glands and crypts are less active in the production of their juices. The pepsin is also weaker. Action at the pyloric orifice is feeble, and the tissue here is often the seat of disease, the cause of which may be in other portions of the body.

Lower in the intestinal tract the walls of the bowel, as a condition of advanced age, assume an appearance of opacity, showing that the blood supply is less than in youth, from the clogging-up of the minute capillaries which supply the glands and crypts whose office it is to secrete the intestinal fluids necessary to digestion. This obstruction is due mainly to fibrinous products which accumulate here and create a condition of impermeability to the nutritive particles. The same lack of permeability is seen in the *villi* which hold the lacteals. Thus absorption, on which life as a process rests, is restricted and gradually diminished. The failure of function, so far as can be determined, appears as a concomitant, and is probably a resultant from the deposition in these tissues of fibrinous substances. From such damages to the digestive organs we find that the food is improperly digested, and that such portions of the chyle as reach the walls of the absorbents are only in part and tardily taken into the circulation for purposes of nutrition.

In the reproductive organs, particularly those of the female, the effect of time changes are very marked. These changes are of two kinds: first, those which are manifested in alterations and depositions like those observed in other tissues; second, those which mark in the female sex the inception and cessation of the phenomena of ovulation, menstruation, and gestation.

According to Mr. Darwin's theory of heredity, ovulation and the formation of spermatozoa in the male are due to the budding (gemmation, gemmules) of the "cells" of the organism, all the cells of every organ and part of the body contributing gemmules to each and every ovum or spermatozoön. And if this hypothesis be not entirely correct as regards the nature, size, and

form of the gemmules, a process somewhat similar undoubtedly takes place. The cessation of the process of ovulation and menstruation at the climacteric of womanly life, indicates that a period of organic development has been reached when the living matter can no longer emit those particles or vitalizing influences which appear to be embodied in ovum and semen. The cause of this cessation is the decline of the living matter below the quantity necessary to sustain the function. The special organs themselves appear to suffer not otherwise than do the other tissues. In old age, the *testes* shrink, shrivel, toughen, and in some cases appear to harden, in others to grow flaccid, till it is difficult to distinguish their presence in the scrotum. The semen becomes altered in composition and diminished in quantity, corresponding to the changes in the producing organ. The erectile tissue, too, loses its property of dilatation from the progressive obliteration of the capillary system.

Independent, too, of the wear and tear of impregnation and child-birth, the *uterus* after forty-five shrinks in the extent and thickness of its muscular walls, and the masses of unstriped fibre lose color and tonicity. The pyriform shape of the organ is gradually lost, while its interstitial tissues appear to have hardened.

In the male, Cowper's glands diminish in size as the individual grows old; while the prostate (from secondary causes) enlarges, often being found, on section, to contain small concretions of earthy matter, largely carbonate of lime.

The number of ova produced by the human female does not much exceed four hundred, though a rudimentary capacity for developing many thousands is indicated in the microscopic ovisacs of the ovarian germ epithe-

lium. But the stroma of the ovaries, after the manner of other tissues, gradually shrinks and grows too firm and tough to allow the maturation of the Graafian follicles. The excess of vital power necessary to their maturation, too, is wanting, from the decline of the other tissues.

Some microscopists have claimed to find that the ovaries possess a potential capacity of producing as many as a hundred and fifty thousand ova. At the lower computations of other authorities, who place the germ ovisacs at sixty thousand in number, a woman possesses, rudimentary, the capacity of living, fruitful, a life of from four to five thousand years, as against the twenty-five years of her present fecundable existence.

In the organs of special sense, sight, hearing, taste, smell, which constitute the higher development of an animal organism, we perceive the havoc wrought by life's wear and tear, displayed in a manner strictly analogous.

The eye exhibits shrinkage of its globe from a progressive elimination of its biogen, and the substitution in its place of dryer, firmer, lifeless "formed matter." As a result there is less fluidity and mobility; and the flattening of the globe, causing presbyopia, follows as a secondary result of these changes. Many of the more common diseases of the eye have their causes in mechanical injuries, the strain of over-use, or are secondary to diseases of the general organism. But there comes, as the pure result of the general wear and tear of life, a condition which manifests itself in "far sight." In the retinæ of aged eyes, examined in *post mortem* cases, there are sometimes deposits of calcareous matter, while more frequently there is a marked increase of fibrinous and connective tissue which always implies a corresponding decrease of the true living elements.

The "humors," or fluids, which it is the office of the ocular tissues to secrete, are lessened in quantity and deteriorate in clearness and light-transmitting qualities. The senile forms of cataract, too, are held by Cooper, Middlemore, and Mackenzie to result from defective nutrition and other tissue changes which mark the decrease of the living matter. In advanced age the cornea becomes harder, more brittle and less pervious to the passage of light. In many cases it is found quite devoid of the living element, — a mere segment of "formed," non-living matter. The entire sclerotic undergoes similar changes. There are many instances of the deposit of earthy matter in these tissues. Scarpa, in his treatise on *Diseases of the Eye*, speaks of an eye which had turned almost completely to *stone*. Haller has recorded a similar instance, and Hildanus, Lancisi, Morgagni, Morand, and Zinn mention cases of well-defined calcareous deposits in the eye.

Calcareous and other deposits of earthy matter, however, must never be regarded as directly deposited or produced by biogen in the tissues. They are always secondary, and the results of diseases or general vital failure in the organism to remove waste. Such deposits then find lodgment in tissues where the biogen has become abnormally diminished and thinned out. This diminution and thinning-out begin from lowered vital power in the organism after the adult estate of the animal is attained; and the cause of this lowered vitality is from excessive draughts upon it for purposes of labor, reproduction, sensory pleasures, and from the lowering of the morale of the individual, on account of the many pains, injuries, and disappointments incidental to life as we at present lead it. The normal, necessary stimulus to live in the full sense of the or-

ganic needs is thus felt less strongly; the vital reaction from it is consequently less; and the impulse to proliferate in the histological elements, or "cells" of biogen, in the tissues, to proliferate and fill the tissues with living matter, is less intense, and, as a result, the "formed matter" is not expelled and absorbed in proper measure. This excess of formed matter in the tissues furnishes the *nidus* in which calcareous deposits find lodgment.

Furthermore than as above described, the condition of old tissues appears to be one where a certain amount of shrinkage of the living matter is associated with an excess of "formed matter," and also — what would naturally follow — a diminution or an undue increase of fluids, either of which conditions marks abnormal absence of biogen. The "cells" of these "aged" tissues are fewer in number, less intimately connected by what Heitzmann terms the "filaments of bioplasm," and as a rule, smaller in size and more compressed by their non-living environment. In this latter particular, the condition of numbers of examined "cells" often appears to be one approaching incarceration, or invagination, by the "formed matter." Certain of these "cells" which were, presumably, in earlier age, connected one with another and easily accessible by the blood plasma, through their cell walls, are here found thickly ensheathed or isolated as in a matrix; sometimes so deeply embedded and remote as to suggest the "toad-in-the-rock" condition. That such cells are active or contributing their quota of sentience to the organic stock of vitality, is not probable. Little or no nutritive matter can reach them; they seem torpid, as are animals in a state of hibernation.

As the organism ages there is a well-marked ten-

dency on the part of the biogen of the most of the tissues to assume more of the "cell" appearance; it seems, more than in youth, to live in "cells"; and as the organism declines further, these *cells* of biogen grow smaller in size, assimilate food particles with less rapidity, and form tissue products more slowly. This condition, marking age, has been argued as indicative of the theory of a *qualitative* decline in the substance of biogen, but can be shown to be a result of causes having no influence upon the intimate vital constant. We claim this confidently, while admitting that there is what may be classed as a progressive diminution of size in the "cells," corresponding pretty closely to the age and life-rate of the man or animal.

Differentiation has its dangers to individual life as we at present lead it. The stress upon biogen in the organism to differentiate for the production of the various kinds of tissue needed in the organic apparatus is, in adult life and old age, unduly potent, and renders the biogen too much the agent of mere subordinate tissue-making. The "habit" or "taste" of these "cells" in the special tissues, as of bone or muscle, becomes too much fixed, too much inclined to this special sort of pabulum and production. The general sense of feeling is too far sacrificed to this special function; the biogen becomes too much differentiated. An organ, as the liver, for example, tends to become too much merely liver and nothing else. In youth the biogen of this tissue possessed more of general sensation and of the sensibilities of undifferentiated biogen. So of other tissues and associations of tissues: an arm, or a leg, as the organism ages, tends too much to become merely an arm, or a leg, good only for the purposes of a mechanical instrument, and too little sentient as a

living part of the organism. The excessive progress of differentiation of tissues gives rise to peculiar conditions wherein the entire organism loses in general sensibility, and becomes more exposed to disease. Weakly or diseased parents, too, transmit to their offspring in the germs of life a smaller measure of living matter. A weakly ovum may indeed develop to the type limits as regards size, but the "cells" of the tissues from youth onward will be found less rounded and smaller. Sometimes it is but the biogen of a single tissue, or organ, which is scanty and weakly; but such is the co-ordination of tissues and tissue-lives in the organism, that this one weakly tissue depresses the vital tone of all the others; just as in the aged condition this same co-ordination and mutual dependence of tissues involve the entire organism in a simultaneous and co-related decline, where each tissue or organ both drags down and is dragged down into senility by each and all the others.

Not that we deem the point entirely settled that senile deterioration of biogen, or inherited deterioration from weakly parentage, does not represent a physical difference in the internal molecular composition of the living matter itself, as *e. g.*, a closure, or opening of the arcs and circles of molecular, vibratory motion, or changes in the proportions of the component particles. But in most instances where either senile or inherited deterioration of biogen in tissues has been examined, the condition was quantitative, or could be directly traced to quantitative dimunition of the living substance.

Still another phase of aged tissues, as touching their histological elements, is a tendency of the "cells" or living matter to fall into a condition of uneven distribu-

tion in the tissues, thus leaving unequal spaces betwixt cell and cell, and unequal areas of "formed matter." There is sometimes observable, too, in old tissue what looks like agglomeration of the biogen, as when on a pane of glass the collected moisture, upon a slight decrease of temperature, runs together in larger drops.

It is a still mooted point whether fibrin is to any large or uniform extent deposited directly in the tissues from the blood. There is considerable reason to believe, however, that it is so deposited in feeble organisms, and adds its lifeless weight to the "formed matter" as an obstacle with which the living matter of a tissue has to contend.

In regarding the subject from this stand-point, it must not be overlooked that normal ossification and the accumulation of formed matter are natural and necessary conditions, within normal limits, to preserve the integrity of the organism and prevent undue growth. It is the regulation of these natural and needed processes which will fall within the domain of vital physics.

To determine when the formed matter of a tissue, as in an arm or a leg, has accumulated to the extent which best serves the purposes of strength, sensibility, and the health of the biogen therein contained, and to regulate it at that quantity, will be one of the problems of that science in the near future; for so surely as we live we "grow old" from the excess of such formed substances in the organism. This reopens the question already touched on, why "formed matter" accumulates in an organ or tissue beyond its needs and to its detriment? Why is it not eliminated and thrown out from the organism naturally, and why should we need to have recourse to art to assist us in its elimination?

The question was at one time answered by bringing forward the theory that the biogen of a tissue had, at the outset of life, a certain initial power to live, and that as this modicum of vital power was expended, the action of the biogen grew weaker. Hence it failed to reproduce itself, shrank in volume, and as a result of this weakening and shrinkage, non-living matter, the dead residuum of once living cells, remained in its place, giving to a tissue its familiar "aged" appearance. More generally, that life in a man, as in a tree, had its measured capacity for growth meted out to it in the seed, or ovum; that it grew to the extent of this initial, primary, measured capacity, then declined to its death; and that this fixed measure of vital power was from an absolute law of life.

To the fallacy of this theory of vitality reference will be made hereafter.

Another of the causes of the diminution which the biogen or living matter undergoes in adult and aging organisms is the drain upon it set up and sustained by the reproductive impulse. This impulse, and the resultant drain on the individual life, is in reality a mode of growth on the part of the constituent biogen after that the organic limits are reached. But normal growth is retained in the organism, whereas growth through the reproductive organs is thrown off and takes the form of vital waste. Reproduction thus becomes a species of self-immolation, a mode of death, that we may live again in offspring. Within due bounds it is not materially exhaustive, as for example, the ordinary purpose of procreation; but practically it becomes excessive. The seminal economy of most males tends as surely to exhaust the organism and ultimately bring it to a stand-still, as the horary action of a clock causes

it to run down. The human female expends her vital power, perforce, for a certain number of years, in the production of ova. The human male is not so much bound by necessity to part with his vital power, but does so practically, however. Furthermore, it is not wholly dependent on the circumstance of the spermatozoa being cast out of the organism, whether the drain into the reproductive organs shall take place or not. The very fact of the existence of these organs in the organism probably sets up a draught on the other tissues, tending to the formation of germs. The re-absorption of spermatic fluid, formed in the generative tissue, into the organism, acts rather as an irritant to stimulate it to a short-lived phase of strength and physical beauty, rather than as a force to insure long life and intellectuality. In other words, the stimulation of the reproductive sphere, with continence of its seminal product and its re-absorption into the organism, tends to a certain handsome yet animal type of development, accompanied by those hirsute, deep-bass features which we see more markedly in the lower orders of animal life; a development the cycle of which is transient from its very nature. The truer vital economy is to retard to the last degree the secretion of the reproductive organs, thus diminishing the drain on the living matter. For, granting that the theory of gemmation, or some modification of it, is true, that gemmules from every "cell" in the body go to make up every ovum, or spermatozoön, it is more than doubtful if these absorbed spermatozoa are ever re-distributed to the parent "cells" in the various tissues, or absorbed otherwise than as an irritant, or stimulant to farther gemmation.

This consideration of the cycle of the reproductive sphere leads to the still broader subject of general vital

stimulation, it being held by many, and doubtless correctly, that all vital phenomena arise from or succeed to stimulation of an irritant nature; in short, that we live only as the biogen within our bodies is stimulated by contact with, or influence from, the external world. To this doctrine has been wrongfully superadded the hypothesis that this inherited biogen which we find ourselves in possession of through our parents, will respond to irritant stimulation only to a certain extent, through a certain period of time, more or less definitely fixed, at the end of which time it will become irresponsive to such stimulation; or, in other words, is exhausted from its source. This hypothesis is formulated more succinctly (as above mentioned) in the statement that we inherit a fixed modicum of vital capacity from ancestry, in the ovum and the spermatozoa, which is expended, like the coiled impulse in a watch spring, during the allotted lifetime of man; that terrestrial life naturally expends it and brings it to extinction. To controvert fully this latter superadded hypothesis, we have but to cite attention to the fact that life on earth — man if you please — began in lowly, minute forms, and that there has been a constant progress upward to higher forms; in other words, that what once stirred feebly as an amœboid particle of biogen, now walks the surface of the planet as a man; which means that the *child* as a rule is better than the *parent;* that, as a rule, the child is more highly developed and more intellectual than the parent, or that there has been something more than a mere repetition of the parent in the child; that the rule is, in the long run, that the child is of a higher type than the parent; and this means nothing less than that there has been a *creation in the child of something not possessed by the parents.* Can the ancestral amœ-

boid particle, feebly stirring the slime of the primordial sea-coasts, vie with, or compare with, its child, the full-grown man of to-day? Yet, the difference between that living particle of the old time and the enlightened man of to-day is referable to a steady accumulation of creations in the myriad child links which span the enormous arch of progress here exhibited. This grand vital progress from lower to higher forms is the tangible fact which once and forever disposes of the mere insufflation hypothesis, — an hypothesis which makes all progress an impossibility. It demonstrates that the external world is capable of furnishing to us a stimulus which shall enable us to create vital capacity as well as to expend the vital capacity inherited.

Granted that under unfavorable conditions the child may sink below the parent, we can yet claim that under favorable conditions the child may exceed the parent; and that this is the rule and the law in the phenomena of terrestrial life.

There is, then, possible in our organisms a *creation* of what has not previously existed on earth. What does this imply? Nothing less than that the living biogen in our tissues may, under stimulus, and when properly supplied with matter from which it is able to renew itself, improve on its original endowment, increase it, and make a better physical organism than it could make were it possessed simply of the capacity to repeat the parent. The external world, then, possesses this control over the individual, that it may impel it to do better or also worse than the parent. Life is not, therefore, the bond-slave of heredity, even in the most far-reaching sense of that term, but possesses in the individual animal a certain power to depart from, to excel, or to sink beneath the parental stock.

If, therefore, there may be a creation of new power and vital capacity, what are the limits of this new creation, or is it limited at all? Is not the problem one of rendering the external conditions so favorable as to induce a continuous new creation of such vital capacity?

The better to understand the proposition, it may be well to analyze the stimulus which the external world furnishes to a living creature. What is the nature of this stimulus, and in what is it embodied, and what are its methods? The biogen of the tissues has brought to it by the blood partially vitalized particles, which, being of the nature, chemically, of the living matter itself, are absorbed by it, and go to nourish it, to supply the waste of the vital process and increase the bulk of the biogen as exhibited in growth. This contact of assimilable particles is held to furnish to biogen a stimulus of an irritant character. The process is not different save in external details merely from that by which the amœba is nourished and stimulated in the water slime. It is still the primitive method of stimulation, the method by which life exists in its lowest forms. But in the higher types of animal life, possessed of organs of special sense and locomotion, stimulus from the external world can be received more widely and variously. The progress indeed toward such special sense development may be regarded as a blind reaching-out of hands on the part of the helpless, tender primordial biogen for increased stimulation and knowledge of the external world. By means of this increased power of obtaining knowledge of external objects, the air and the luminiferous ether, so called, are made vehicles for gaining impressions of distant objects, as well as merely by contact with contiguous matter, and locomotion and the development of muscular power otherwise assist in the further observa-

tion and examination of external nature by means of contact. The organs of smell and taste, too, aid largely in the work of intimate examination by contact. The senses which arise from the localized concentrations of the general sensibility of the living organism, open grand avenues for the in-rush of impressions from the entire universe, and it is from the action of "sensory impressions" upon the biogen of the nervous system that the organs of mentation and intellect have been raised up.

Impressions from without, then, have the power to act on and transform the quality of the living matter, and tend to educate and refine a certain class of tissues. It is not likely that this development and growth of a refined variety of biogen affect the quality or sentient powers of the ultimate "atoms" of matter, but that improved nutrition, combined with an increase of impressions from the external world, acts as a refining and perfecting agent in that wide field comprised within the internal structure and arrangement of the molecules of living matter.

Through this perfecting process new creations of vital capacity are accomplished. The physical exponents of these new creations are refinements of the living matter and increase in its quantity. The child excels the parent. The agencies of this excellence are both improved facilities for nutrition and a wider range of impressions from the external world.

We may summarize the action of impressions from the outer world upon a given organized mass of living matter forming an animal, and express a law of its action as follows: From the universal sentience of matter it results that the more in relation with the external world any organized mass of living matter stands connected, or, in brief, the more matter it sets up commu-

nication with through its various modes of receiving impressions, the more highly sentient it will become, and the more highly organized it will grow. In man we behold, as a result of his wide knowledge of the external world, acquired through his senses and those of others (recorded in or conveyed verbally by language), the development of a large brain and a superb nervous system. Nevertheless, this superstructure is reared upon a basis of biogen not thus refined, biogen of lowly sentient condition. We have thus presented the phenomenon of a higher grade of living tissue, developed from sensory impressions from the universe about it, resting on and dependent upon a system of variously developed tissues of lower grade, seen in bone, muscle, cellular tissue, hepatic tissue, blood, *et als.* We behold a well-nigh divine intellect resting on and dependent for its existence upon the most primitive form of sentience exhibited by biogen; in other words, pardonable, we hope, we see a demi-god grafted on a brute or a vegetable stalk, a being who has for centuries felt his insecure and ignoble situation, and dreamed of a life not connected with this "frail clay." The next phase of his progress in knowledge is to wake more fully to his fate, and set about the husbandry, cultivation, and protection of the "frail clay" itself, to make it completely his servant and the instrument of prolonged existence.

From the action of gravitation and the co-related forces which move and control the great mass of matter aggregated in the earth, biogen, of which all life forms are the growth, is subjected constantly to severe physical action and many violent and destructive vicissitudes. Although, as we believe, all matter universally possesses the property of sentience and is capable of ex-

pressing the property in terms of what we call life, yet from the action of the physical forces above mentioned, the complex substance, biogen, containing at least five of the so-called material elements, is the only one which is sufficiently mobile and internally plastic enough to be able to move in obedience to stimulus from the outer world; or, in a word, to live and develop higher forms and types of life from those lower unicellular forms in which it is first seen to stir and move. Now, while it is through the agency of these same physical laws, expressed as chemical action and mechanical movements of matter, that the stimulus is conveyed to living matter, causing it to live, grow, and develop, yet these same forces often act excessively and cause the death and dissolution of the living substance; and thus death is in the world. Life on earth has always been a continuous struggle to live, often under highly unfavorable conditions. The lower orders of living creatures struggle for food and to escape death at each other's jaws: a struggle which occupies all their energies. Of the hostile action of the elemental forces upon them, they take little heed, though constantly perishing from this cause. With man the struggle, though essentially the same, takes a different phase. In the civilized state men labor, indeed, for food, but there is less of the grim, life-and-death grapple for simple sustenance, and far less fear of actual violence and death from each other, or from other living creatures. The contest is rather for luxuries, so called, than for food, and for fame among their fellowmen, and for the accumulation of property; and to some extent, too, we find men devoting their energies to ward off the destructive action of the elemental forces, surrounding themselves with better sanitary

arrangements for preserving health and life. We contemplate a certain per cent of human beings uniting in a guild or confraternity and making it their business to combat the various diseases which the action of the elemental forces engenders. True, their efforts in this direction are often, after a purblind fashion, embarrassed by antiquated methods, and exceedingly earthy in the administration of more or less deleterious substances which bear the name of medicines; so that it is an oft-mooted question among the laity, whether or not "doctors kill more than they cure." But they probably do not, and their efforts are on the whole meritorious.

Another equally large guild has undertaken the regulation and control of the moral natures and emotions of their fellows, with much the same amount of embarrassment from antiquated tenets and traditions, and about equal success as to the results obtained.

Still a third guild has attempted the protection of men from their fellows, in the codification of customs and the regulation of individuals in the social state.

All these have their place, and are of like importance in the progressive amelioration of life on a primitively rude and tumultuous globe of matter.

It remains for men to so subjugate and control the elemental forces, that they shall be their servants and not their destroyers. Thus far but a very measurable progress has been made in this direction. The inception of a new era of effort and progress is at hand, however, and the next half-century will witness grand achievements in this direction.

As has been observed, the death-dealing agencies with which we have to contend in this age of the earth and of the race are less of the nature of visible, palpable violence than formerly, though accidents from

mechanical violence, incident to our modes of life, are still frequent, perhaps never more so. But of violence from other living beings, including our fellows, we have now comparatively little to fear. Our foes are of a more intimate nature. In the living matter, too, which forms the woof of our bodies, we have inherited from our parents tendencies to various diseases, to combat which often requires more wisdom and energy than we possess.

There are also among the causes of the decline of living matter in organisms, the excessive drying action of heat; the constrictive action of cold; the incessant action of gravitation upon the fluids of the body, and the thousand vagrant chemical activities of the food substances which we ingest; the ceaseless yet variant pressure of the atmosphere upon our bodies, and the irregular tension of the electric and magnetic forces; and, added to all these, the constrictive action of the "formed matter" of which our bodies are built up, namely, the tendency of this formed product of the living matter to constrict, bind out, and limit the living substance itself.

VI.

THE ARGUMENT THAT LIFE IS FROM A CONSTANT IN NATURE.

Advancing from these particulars of our subject, we come to a question which it is the object of this investigation to raise, namely, Can we entertain any reasonable hope of prolonging our lives in organisms on the earth beyond the present time limit; prolonging them to a hundred and fifty years, two hundred years, or more; indefinitely, let it be said?

The hypothesis of life at present held by many savants and medical men is, that every human being inherits from ancestry in the fecundated ovum in which life begins a certain amount of vital force, a certain capacity for living; that no more is ever vouchsafed to that individual, and that by no act of his own can he add to this inheritance. From the moment of birth, or of embryonic development, he begins to expend this modicum of life capacity. Gradually it unfolds, displaying the phenomena of bodily and mental growth, attains its acme in the mature organism, and wanes in the aged one, — a wondrous, coiled, elastic spring which gathers strength as it uncoils up to a certain point, then weakens to a final cessation of impulse. According to this theory of life, from first to last no iota of vital capacity is created to add to the original inherited stock in the ovum. Hence, from the moment of our begetting, we develop from the expenditure of the primary life impulse, and

advance to vital extinction with a not uncertain pace, over a not uncertain route, which can by no possibility be much prolonged.

In the living matter which forms the material basis of every animal organism there is, according to this hypothesis, a steady retrogression which marks the sinking of the hand on the vital gauge. It is held that there is a qualitative depreciation in vital efficiency of the biogen in the tissues; it loses tonicity intrinsically as years pass, and hence becomes less competent to prepare its natural product; less active, less avid to absorb pabulum and exclude deleterious matter. In a word, that it fails from its source as the organism ages.

This hypothesis would thus hold that a living creature — a man, *par excellence* — can live only a "lifetime" defined within certain definite limits, and that, however favorable may be the conditions of his existence, however good his food, air, and climate, however pleasing his associations, he inevitably exhausts his vital stock in living, and dies as inevitably, if not as soon, as if all these conditions had been execrable; in fact, that the very favorableness of these conditions may lead to a more rapid expenditure of the non-interest-bearing capital of life.

Illustrations are brought forward, in evidence, from experiments on the lower animals, *e. g.*, the ox, which, in beef-producing localities, can now be urged forward by better, richer foods of clover and corn to exhibit the same size and *quality of flesh* at two years of age which, on a more meagre diet, would not be attained till the fourth and fifth years. This is but one of many such illustrations.

Another illustration is derived from the appearance of the tissues of aged persons, as compared with those

of persons in the prime of life, and of these latter as compared with infants.

Finally, what is to many the most striking illustration of all, that thus far in the development of life all living creatures have died, without exception, after a not greatly variant period of existence.

Certain it is, that if this hypothesis, which we have endeavored to present with entire fairness, be a correct one, man on earth will die indubitably to the end of time, and that from a fiat of Nature. His doom is fixed; his death sentence as an individual is recorded.

Before accepting so final a decree, announced even from eminent authority though it may be, the fond human heart, which shrinks to sink into dust, will still scan the premises for some means of escape, some ray of hope, remembering that savants are but men, liable to error. Indeed, the very finality of the hypothesis, and the sweeping conclusions from it, would lead us to view it with doubt, since nowhere in nature do we find laws operating with such entire freedom from exceptions to such length in details. Nowhere else do we observe so sharp a line cutting through the thick and thin of physical phenomena.

Let us light up the subject with such facts and deductions as are fairly faithful to it.

Take, for example, one of those minute, unicellular creatures of the infusorial order of life: an amœba, let us say, the body of which may not exceed the twenty-five hundredth part of an inch in diameter, not unlike one of the individual "cells" of the human body, or one of the white corpuscles of the blood. How does such a creature live? What is its vital economy?

First, what is the material composition of such a creature? We shall find that it is, in its living parts, a

tiny mass of biogen, which is composed of a large number of "atoms," or molecules of oxygen, hydrogen, nitrogen, carbon, sulphur, and phosphorus, common elements of the earth and air, differing here in no wise from their ordinary character, save that here they are associated in a particular way, forming a semi-fluid substance; and that, as a consequence of this peculiar arrangement of the component particles, *they can move*, or, in other words, express their natural sentience in motion, and hence *live*.

Observation of such a creature's vital economy shows that it is subject to all the vicissitudes, on a small scale, which larger organisms experience. It is locomotive, that is to say, it moves from an impulse resident within itself. It is contractile; it is irritable; it is receptive and assimilative; it is metabolic and secretory; it is respiratory and reproductive; finally, it is subject to death from mechanical and chemical causes; in a word, it shares the common lot of all living creatures, and may exhibit more intensity of action, more vital energy, in youth than in age. Certain particles may get within it along with its food which distress it. It may be poisoned, or some larger type of infusorial life may seize it as a prey, and make use of it as food, thereby destroying its individuality, and incorporating it into other forms. Such vicissitudes are the results of the conditions of its existence; it is the common lot of all terrestrial forms of life from amœba to man.

The little mass of biogen, constituting a unit of life, has been crushed, poisoned, or otherwise *killed*, and its component particles of oxygen, hydrogen, nitrogen, carbon, sulphur, and phosphorus have been scattered or taken into other vital units. The amœba is "dead," but the sentient particles of which it was composed have lost

not one whit of their power or capacity to live in other units or animals. The grouping or association of them in this particular amœba is the only thing which was "killed" and is "dead." Each atom or molecule of oxygen, hydrogen, nitrogen, carbon, sulphur, and phosphorus has its indestructible quota of potential sentience. Death, as we know it, has no power over the "life" of an "atom."

This initial life-power is a constant which no cosmic disaster has ever yet been able to act on or disturb.

It is a constant, just as its co-relative, gravitation, is a constant, and indestructible as matter itself. From it proceeds every manifestation of physical force universally. It is the source of every mode of energy, the eternal well-spring of Nature in all her varied phenomena.

Here, on this eternal constant, the intimate life of matter itself founds the hope of a possible immortality for man. No vicissitude of earth has yet been observed to deteriorate its quality. Everlasting as the stars, it shines from the core of each ultimate particle of matter, and illumines the wide deserts of space with the glow of life.

The death of the amœba was purely of the nature of an accident from its surroundings, not a destruction of its component sentiences; and what is true of the amœba is true of every living creature that has ever lived and died.

Mark well the distinction, for it is finally important. The popular hypothesis of life, death, and "old age" rests on the assumption that life is *qualitatively* diminished in aging organisms; or, in other words, that vitality, as a physical process, slackens from variability of its originating force, and hence that death comes to a

person from this decline of the initial vital power in the organism.

But if our argument be logical, and our conclusion correct, the truth is that life is never *qualitatively* but only *quantitatively* diminished; or, in other words, that vitality as a physical process never slackens from any variability of its originating force, that force being the universal sentience of matter, and as constant as gravitation and the weight of the earth; and hence that death comes to a person, not from a decline of this initial vital power itself, but from those extrinsic obstacles which befall from the material environment and from imperfect modes of living. Further, that the apparent wave-motion of life in organisms, namely, those periods of alternate increase and decrease of vital quantity in a living being, is but the natural and everywhere-observed ebb and flow of a primarily constant force, surging in billows at extrinsic obstacles to its action.

Death comes to us, then, not from a law of nature. The law of nature is life, not death. Universal matter *lives* from eternity. It never dies, not even the least particle of it, but lives immortally. Life is the grand law of the universe from eternity to eternity.

Our problem is to make a certain definite mass and form of living matter — an organism — live on this earth as long as the organism shall *will* so to do. This is the present drift and goal of human achievement. But at present the human organism lives badly and falls victim to a thousand vicissitudes, the result of which is its cessation of function and dissolution. But the problem is ever one of ways and means, and essentially a terrestrial one.

What we believe the truer hypothesis of a human life is, that in the fecundated ovum we inherit various

kinds of biogen or living matter, which have received from our ancestry a bias, or plan of development; or we may say that these various kinds of biogen in the embryo have certain inherited instincts and inclinations as to their food; and that these food instincts, or tastes, lead them to grow as they feed, this one into bone, that into muscle, etc. But so far from an ovum containing all the capacity for life which the organism will ever be able subsequently to exhibit, the fact seems to be that any atom of carbon, oxygen, hydrogen, nitrogen, and sulphur, taken into the organism as food and incorporated into the biogen as an atom of it, brings with it its own sentience, its own capacity to live; and from the moment of its incorporation into the biogen to the moment of its transformation into "formed matter," it constantly contributes that sentient impulse to the organism's general stock of life.

Many tons' weight of such atoms pass through the organism, as food; and a great number of them are actually incorporated into the biogen, and, for a certain period of time, form a part of it. Each and every such atom, so long as it is in our personal biogen, vests its sentient constant in our personal lives. Departing, its quota of sentience is withdrawn and that of an incoming atom takes its place. The "cells," or little masses of biogen, rapidly grow by assimilation of food and self-division; and that tiny mass of living matter which formed the ovum in which we originated, constantly divided and each sundered fraction distended with new food particles, soon retains little of the original material; yet the in-rushing atoms fall into line and assume the same characteristics as their predecessors, whether as bone-makers or muscle makers. There is a wonderful impressive power in the inherited biogen of

the ovum. It has the ability to stamp its traits and instincts upon its enormous growths for years, many thousand-fold its original substance. The real method of this impressive power is probably one of atomic and molecular arrangement of the newly incorporated particles. These are placed by the growing biogen in certain positions, relatively, to each other, and hence display variant affinities, or tastes for food particles, in albumenoids, or in lime salts; in other words, such chemico-vital affinities are a matter of atomic arcs and orbits.

Nor yet is it probable that the embryonic biogen — that inherited in the ovum — is wholly instrumental in perpetuating the different kinds of tissues in the organism throughout life. The same impressive power which first directs growth from the ovum in the embryo, and adapts the growth of tissues to the wants of the organism as an individual animal, is constantly generated by these wants and necessities. The same agency which, in the parent, produced, on a small scale, embryonic tissue of bone and muscle, constantly acts in the active, living organism to generate the same permanence in reproduction of the needed tissues. So long as the organism remains, from a vital point of view, in accurate function, in good health, so long will there be no perceptible deterioration in the renewal of the tissues. The reproductive ability will remain in them unimpaired. The needs of the organism — the same agency which first effected the differentiation of tissues — act constantly and effectually to make the needed differentiation permanent and the organic type stable.

Indeed, these needs and necessities may even act to better the type, and make the offspring superior to the parent. Or the needs and necessities, changed a little from altered climatic, geographical, or food condi-

tions, may produce progressive improvement in the organic type. The son may excel the father; and the plan inherited in the ovum may be improved on; whereas, were the previously mentioned and commonly received hypothesis of human life correct, there could be no such thing as progress. Were that hypothesis true, in fact, there could never have been any progress in the development of life on earth from lower to higher types of organisms.

"Old age" is often largely a slow starvation of the living matter in the organism. We are speaking of "old age" here in the popular sense, considered as a cause of death. To the biogen of the tissues "old age" is a time of famine. If the principles on which we believe living matter founds and exists are operative and real, biogen is not itself intrinsically affected by time; for it may be constantly renewed, and when renewed remains forever young. The sentient attribute of matter, from which it *lives*, is an impulse persistent forever at a uniform pressure; as uniform as gravitation, of which it is the primate. Hence, in biogen we need fear no slackening of power, no failure from the source. It is not the sentient constant in biogen which "grows old" in our aging organisms, but the surcease of the biogen from the tissues on account of mechanical causes, connected with growth and the products of growth. Biogen must grow, in order to live. To obtain space to grow within the limits of organs which have reached their hereditary size, the "formed matter" must be dissolved and absorbed by the blood. This is a difficult process to regulate in old tissues; for it may suddenly become excessive as an antithesis of meagre action. As in an old tree, so in an old animal organism, it is with difficulty that the "old" woody

fibre is gotten rid of and replaced by sapwood. To renew the biogen of a limb or an organ *in situ*, where the space is filled with old "formed matter," becomes a grand problem in vital physics, one to which attention will be called in the further course of this investigation.

That wonderful refinement of biogen within the human body about the cerebro-spinal axis, with its appendages, wherein the sensibility of living matter has been advanced to intellect, or "soul," is, like the inferior tissue of the body, subject, though in far less degree, to those accumulations of formed matter by which the biogen is smothered, repressed, and prevented from living. In far less degree, we say, for it is a more vital tissue; that is to say, more vitally powerful to live and renew itself. The ills from which it suffers most in the aging organism are those which result from the shrinkage and loss of vitality in the inferior tissues, in which it lies embedded. It is not too much to say that the cerebro-spinal tissue, *i. e.*, the tissue in which mind is manifested, would endure for two centuries, could the inferior environing tissues be kept good. In "old age," in starvation, and in most diseases, it is ever the last tissue to lose in vitality or in weight. This physiological fact is in itself a grand guarantee of the truth of our faith in man's future apotheosis. That tissue which produces intellect not only contains far the most biogen to the ounce, but is by far the most enduring and defiant of terrestrial vicissitudes. But being developed within, and the sensory instrument of, the inferior tissues, it shares their fate, perforce, and will continue to do so until such time as it can provide for the stability of them all. Yet do these inferior tissues necessarily stand between the intellect and the hard terrestrial en-

vironment out of which man has arisen, and from which he is forced to derive his sustenance.

Nor can we at present conceive of a mode of terrestrial life by means of which intellect, or "soul," can be sustained without the good offices of the menial tissues of the organism. Hence, to renew, replace, and save them from "aging" and destruction, becomes the subject of our gravest care.

In typical "old age" we contemplate a condition of the human organism which is the resultant of an extensive series of checks and hindrances to the natural growth of biogen. Every tissue of the body has gradually grown inefficient and lethargic from the diminution of the living matter in it and the undue increase of lifeless products which fill the space, and are not easily supplanted. What biogen does remain may be, perhaps, as good as any biogen, or as good as any ever in that tissue; but the quantity is small, too small to keep the tissue fresh in color and vital in function. From the shrinkage in myxomatous tissue, the blood has become impoverished in corpuscular elements, and this impoverishment still further impedes nutrition. The thinned and diminished alimentary tract absorbs chyle less readily, and the plasma of the blood is less rich in nutritive particles. All the large glands and crypts where the epithelial elements have diminished, secrete in diminished volume those strong reactive fluids which facilitate digestion. The shrunken tissues, too, call for nutritive matter less avidly than when young; and, as a consequence, the appetite of the old person is often "poor," or capricious. In a word, there is diminution everywhere — diminution of biogen; there is less demand from, and less supply to, all the tissues. The organic business dwindles away with the dwindling

living matter. If we could find means to increase this diminishing biogen, the current of life would soon run stronger again, and the vital function of every tissue would be quickened; for the biogen is apparently not depreciated in quality, only grown less in quantity. A tissue is "old" because there is little biogen in it, not so much because the biogen has grown intrinsically weak. This truth marks the distinction between the new philosophy of life and hope and the old erroneous philosophy of death as an ultimate law of life.

Meantime how fares it with the nerve and brain tissue, the tissue of intellect, in the gradually shrinking, hardening, and sense-thickened organism? Badly enough. From the diminution of biogen in the periphery tracts, sensation is lessened, and sensory impressions to be reported along the nerve trunks to the central nervous tissue are less in strength and frequency. As a consequence, the nerve axes lose tonicity, and even the cerebral tissue becomes inactive and dull at length. Then, too, the diminution of the constituent biogen of the tissues acts to throw abnormal stress and strain to preserve form and sustain function upon what remains of the living matter. Hence those almost constant "tired sensations" which beset those past middle age, who yet strive to support the burden of daily labor, — sensations such as were not experienced earlier in life. Weariness of this kind is common. It comes from the starvation and over-exertion of a diminished measure of living matter in the tissues, — a simple result from a patent cause. Yet it begets in time within the intellect a species of world-weariness; the tired worker sighs, "I would not live alway." The weight, not *properly* the "weight of years," but of formed or devitalized matter within the organic limits, grows sensibly heavier as the

measure of biogen gets relatively less. There is constant physical weakness, and this, as constantly reported to the mental tissue, gives rise there to discouragement and apathy, the mental co-relative of organic enfeeblement. These phenomena point clearly to their cause, to wit, the excessive decrease of the living matter and the stress imposed upon the residue to sustain the corporate offices of the organism. These, and another series within the cerebro-spinal tissue and general nervous tissues, secondary and the resultant from these first mentioned, cover the entire range of "old age" phenomena so far as we are able to observe or classify them. They are demonstrable, when understood, as physical and physiological data; nor is there any reason to doubt that they will prove remediable as soon as the appropriate physical, chemical, and physiological agencies are applied for their alleviation.

There is a time in the life of every fairly fortunate and normally healthy human being when existence is a joy, a well-nigh unalloyed sense of happiness; when earth seems wondrously fair and all nature a source of gladness to the eyes and laughter to the heart. That time, that season of joy, is when the living matter within our bodies is just reaching the adult condition, expanding and as yet unoppressed by the after-load of life's accidents and scars, the clearly apparent result of biogenetic health, and as yet undiminished fulness of the living element in all the tissues.

Such an estate of life is attainable, then, — an estate when life is indeed a joy and worth living, — at least once in our lives, and hence is one of the possibilities of living matter on the earth. That we decline from that condition of health and joy is, as I have attempted to show, the result of (1) minute mechanical and chem-

ical accidents of the nature of constrictions and erosions within the tissues, which result to the living matter from its growth products and the physical strain which the organism daily encounters; (2) injuries from a continuous series of physical accidents which befall the organism externally, from surrounding matter, and internally, from imperfect food and faulty assimilation; and (3) the mental, or vital recoil and reaction from all these accidents, exhibited in discouragement and world-weariness.

These accidents may at times suddenly effect the death and dissolution of the organism, or, working slowly and in conjunction, may occasion the gradual decline of biogen in the tissues, and in time induce the condition known as "old age."

It cannot fail to be apparent, however, that each and every one of these causes of death and old aging *is of the nature of an ordinary physical cause fairly within human power to avoid or remedy, and many of which in fact we are every day avoiding and remedying.* It is the sum total of these causes which has heretofore rendered death a seemingly inevitable sequence to life. Yet not one of them but can singly be warded off by human science and foresight, and if one, why not all? It is a question of ways, means and skill with us, not that we die from any immutable law of nature as heretofore held and taught.

LIVING MATTER:

ITS CYCLE OF GROWTH AND DECLINE IN ANIMAL ORGANISMS.

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VI. The Argument that Life is from a Constant in Nature.

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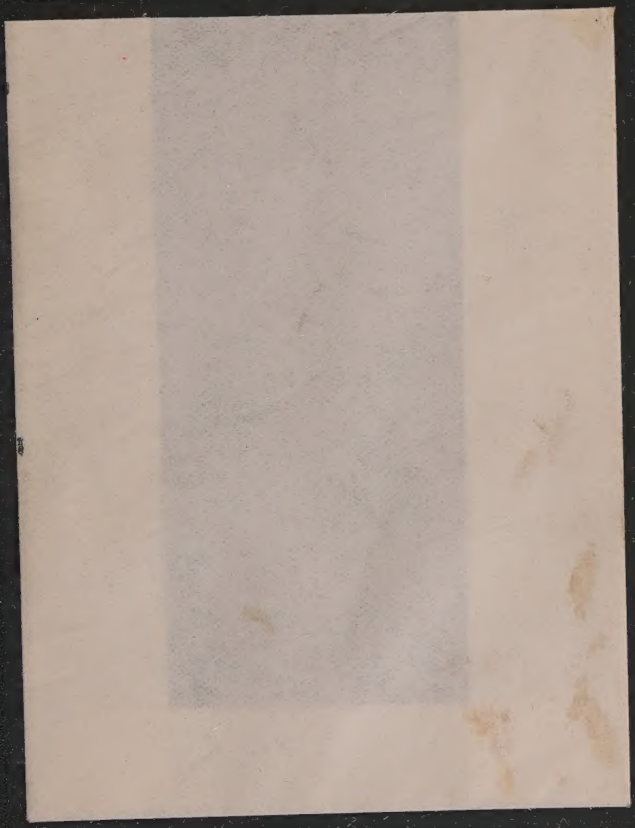

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